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MUSCULAR ATROPHY IN DISEASES OF THE LOWER MOTOR NEURON

Contribution to the Anatomy of the Motor Units

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STOCKHOLM, SWEDEN

THE NERVE fibers from the motor cells of the anterior horns of the spinal cord arborize several times in their distal passage and finally innervate a large number of muscle fibers. A group of muscle fibers thus innervated is generally termed a motor unit (motoneuron) and probably constitutes a functional and trophic unit. For this reason, muscular atrophy due to morbid changes in the lower motor neurons is characterized by the synchronous atrophy of larger or smaller groups of muscle fibers. The most conspicuous example of this type of muscular atrophy is met with in amyotrophic lateral sclerosis, but the same type of atrophy is seen in other diseases.

Darkschewitsch [1] asserted that in amyotrophic lateral sclerosis muscle fibers atrophy in groups. Slauck [2] corroborated this assertion and attributed the phenomenon to the fact that every motor nerve fiber innervates a group of muscle fibers. S. Wohlfahrt and G. Wohlfart [3] undertook a closer examination of the picture of the bundles of atrophic muscle fibers appearing, *inter alia,* in amyotrophic lateral sclerosis and amyotonia congenita. They observed that fibers of sizes peculiar to different groups were often intermingled, an arrangement presumptive of a mutual territorial encroachment of the motor units. Brodal and Refsum [4] performed a biopsy in a case of progressive neural amyotrophy and concluded that the picture on the whole was in conformity with the changes usually associated with progressive muscular atrophies of

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1. Darkschewitsch: Die pathologischen Anatomie der Muskeln, in von Flatau, E.; Jacobsohn, L., and Minor, L.: Handbuch der pathologischen Anatomie des Nervensystems, Berlin, S. Karger, 1903, vol. 2, p. 1220.

2. Slauck: Beitrag zur Kenntnis der Muskelpathologie, Zentralbl. f. d. ges. Neurol. u. Psychiat. **71**:352, 1921.

3. Wohlfahrt, S., and Wohlfart, G.: Mikroskopische Untersuchungen und progressiven Muskelatrophien, Acta med. Scandinav., 1935, supp. 63, p. 1.

4. Brodal, A., and Refsum: Progressive Neural Muscular Atrophy, Acta psychiat. et neurol. **17**:99, 1942.

spinal origin. Hipps [5] studied biopsy specimens from muscles of patients with poliomyelitis and described how the muscle fibers atrophy in groups. He also asserted that "the most logical explanation of the presence of muscle islands is that they represent motor units."

Since 1935, I've made about 450 muscle biopsies and have examined anatomic material post mortem in cases of various types of muscular atrophy. It is the purpose of this paper to describe the muscle picture as seen at biopsy in cases of motoneuron disease. The observations may also throw light on the problem of the anatomy of motor units.

MUSCULAR CHANGES IN AMYOTROPHIC LATERAL SCLEROSIS

Specimens of muscle taken at autopsy in 2 cases of amyotrophic lateral sclerosis were examined histologically. Furthermore, specimens taken in 86 cases of the disease studied clinically at various Swedish hospitals were subjected to biopsy. Only 44 diagnostically clear cases of this material were used for the present study, the clinical diagnosis of the rest not being clearly established at the time the specimens were taken for biopsy. A clinical after-examination in these cases would have been tedious, and would probably have disclosed nothing of special interest beyond that revealed by the present material. Clinical study of the 44 cases, as well as of some of the others, revealed much of interest; but this will be discussed in a later publication.

The microscopic picture of amyotrophic lateral sclerosis is as a rule at least characteristic, if not even pathognomonic. If the typical changes are to be apparent, the specimens preferably should be taken from moderately atrophic muscles. If atrophy is too advanced, one runs the risk of encountering such pronounced changes as obliterate the characteristics of the picture. On the other hand, when specimens are excised from muscles which are clinically diagnosed as slightly atrophic, there is always a risk that the excised material will be void of clearly pathologic muscle tissue. In 5 of the 44 clear cases in this material, two biopsy specimens were taken. The material represented changes peculiar to all stages of atrophy, from very slight to far advanced, a fact of value from a descriptive point of view. The 2 cases with autopsy represented an advanced stage of the disease.

If the microscopic picture of a biopsy specimen of muscle is to be studied, both transverse and longitudinal sections are necessary, the former, however, being far more important in cases of muscular atrophy due to diseases of the lower motor neurons. Different staining methods may be used, that generally adopted for the present material being

5. Hipps, H. E.: The Clinical Significance of Certain Microscopical Changes in Muscles of Anterior Poliomyelitis, J. Bone & Joint Surg. **24**:68, 1942.

a combination of Weigert's hematoxylin and Van Gieson's acid fuchsin–picric acid stain.

As is well known, the cross sectional surface of a normal muscle exhibits coarser and finer septums of connective tissue, dividing the muscle substantially into small parts. The smallest bundles of muscle fibers are called primary. This division, however, is often so vague that it may be difficult to distinguish the borders of the individual primary bundles.

In the initial stage of amyotrophic lateral sclerosis the transverse section of a biopsy specimen displays groups of atrophic muscle fibers scattered over the area of one or a few primary muscle bundles. Sometimes, however, one encounters the atrophic fibers lying together in an area of their own within a primary muscle bundle, in which case they are generally found in a corner of the bundle. The groups in question consist of ten to fifty muscle fibers, all of which are approximately in the same stage of atrophy. As a rule, these fibers differ distinctly in size from those of their environment. Sometimes, however, the individual atrophic fibers may be of varying thickness, owing to different rates of atrophy or to some of the fibers being sectioned obliquely. One may, therefore, be occasionally in doubt as to which fibers are to be considered pertinent to the group in question.

In cases of somewhat more advanced muscular atrophy the muscle picture is very characteristic and is to be considered presumptive of muscular atrophy secondary to a successive degeneration of lower motor neurons. All parts of the transverse sectional area of the piece of muscle examined generally exhibit an essentially similar picture. Groups of atrophic fibers roughly in one and the same stage of atrophy lie intermingled with groups of normal-sized fibers. Figures 1 and 2 show typical pictures. Of importance is the homogeneity of the process over the entire sectional area. In cases of moderately advanced disease and under typical conditions, groups of atrophic and normal-sized fibers are encountered simultaneously in almost all primary muscle bundles. The picture conveys the impression that certain muscle fibers in every primary muscle bundle are more resistant to the pathologic process and therefore survive longer. Sometimes, however, one does find primary muscle bundles comprised entirely of atrophic fibers, but this is exceptional. Occasionally, also, a single normal-sized or slightly atrophic fiber may be seen in an atrophic muscle bundle, probably often a so-called b fiber.

In cases of moderately advanced disease, it is difficult to decide how many atrophic fibers belong to the individual atrophic groups, because they encroach on one another's territory and thus form combined groups. Nevertheless, one can regularly observe individual groups of but slightly atrophied fibers, identical both in arrangement and in

Fig. 1.—Accurate drawings, showing typical parts of the cross sectional area of muscle from 8 cases of amyotrophic lateral sclerosis. The drawings were made with the aid of a projector at a magnification of 200, after which they were reduced, so that the magnification is now about 50. (*a*) biceps brachii of a woman aged 59; (*b*) brachioradialis of a woman aged 63; (*c*) triceps brachii of a man aged 61; (*d*) muscle from the arm of a man aged 37; (*e*) tibialis anterior of a man aged 55; (*f*) biceps brachii of a woman aged 51; (*g*) hypothenar muscle of a woman aged 48; (*h*) brachioradialis of a man aged 39.

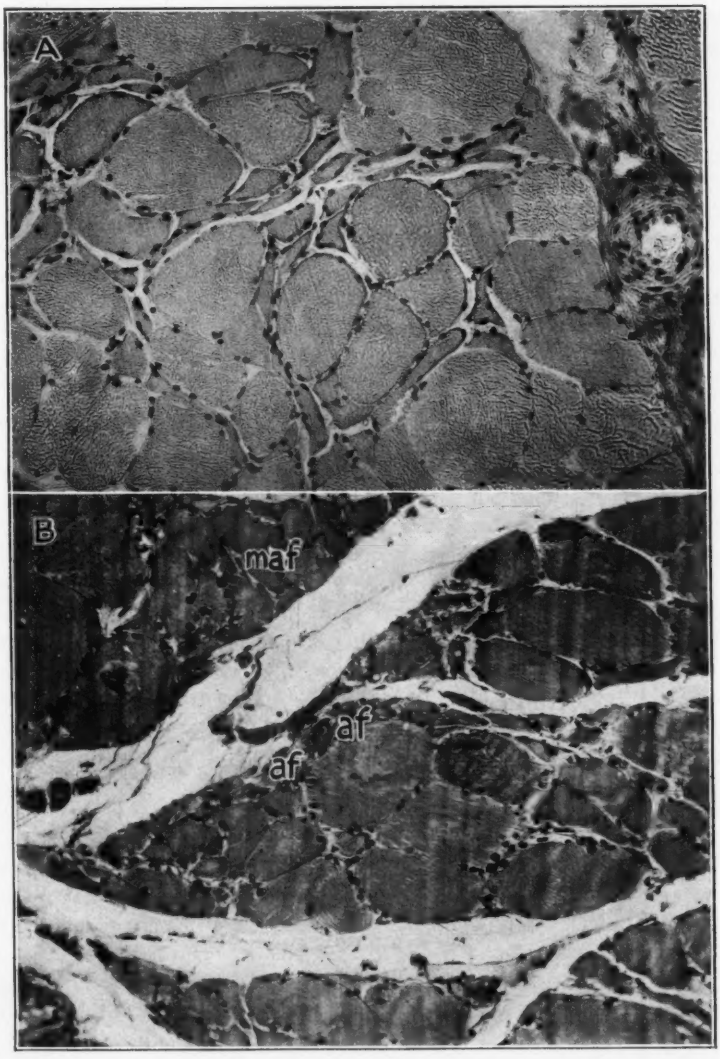

Fig. 2.—*A*, biopsy specimen from biceps brachii in a man aged 43 with amyotrophic lateral sclerosis, showing atrophic fibers among normal-sized ones; × 175. *B*, biopsy specimen from brachioradialis muscle of a man aged 29 with amyotrophic lateral sclerosis, showing successive, disseminated neurogenic atrophy; × 180. A moderately atrophic muscle bundle is indicated by ***maf***; atrophic fibers are designated by *af*.

number with those of the earlier stages. Atrophy evidently occurs rapidly, until it reaches a stage in which the thickness of the muscle fiber is as a rule 10 to 15 microns, after which the pathologic process is very slow indeed. This is the reason that in cases of moderately, and also in more advanced stages, the majority of atrophic fibers are generally in the same stage of rather advanced atrophy, only a few single groups of muscle fibers being but slightly atrophic. This is illustrated in the parts of figure 1, which were produced by the projection of the picture of the muscle on to drawing paper with a magnification of 200, after which the contours of the muscle fibers were traced. Afterward the pictures were reduced to a magnification of 50. Judging from experience, all the traced parts are to be considered as representative of typical pictures, which may without exception be interpreted as disseminated neurogenic (motoneuronal) atrophy. In fig. 1, *a* and *h*, in which normal-sized, moderately atrophic and atrophic fiber groups are all found, are also presumptive of the diagnosis "successive disseminated neurogenic atrophy."

Figure 5 is, admittedly, not pertinent to a discussion of amyotrophic lateral sclerosis, but it is nevertheless fundamentally illustrative of the picture often encountered in this disease. In this case a group of atrophic fibers is seen lying together in a primary muscle bundle.

The last surviving groups of normal-sized fibers are not generally comprised of such a high average number of fibers as are the groups of atrophic fibers, a fact which is to a certain extent surprising. As a rule, these groups contain five to twenty-five fibers. Now and then, however, only a single fiber, or but a few of "normal size," are present in such a group. Moreover, these resistant groups or isolated muscle fibers show a tendency to become hypertrophic (as a consequence of hyperfunction?), their diameter increasing up to 100 microns, or even more.

The atrophic muscle fibers tend to be flattened (perhaps due partially to the histologic treatment), and this phenomenon is so characteristic that in doubtful cases it may be considered evidence of the neurogenic type of muscular atrophy. On the other hand, hypertrophic fibers generally exhibit a round transverse section.

The nuclei in atrophic fibers undergo characteristic changes, in that they soon become round, and, as this change is attended by a simultaneous increase in the size of the nucleoli, they will then be very conspicuous (fig. 3*A*). This modification in the shape of the nuclei and the concomitant enlargement of the nucleoli may often be utilized in practice as criteria for ascertaining the presence or absence of muscular atrophy. These changes appear, however, in other types of atrophy, and not with denervation alone. Sometimes a migration of the nuclei into the interior of the muscle fiber is observable. There is, however,

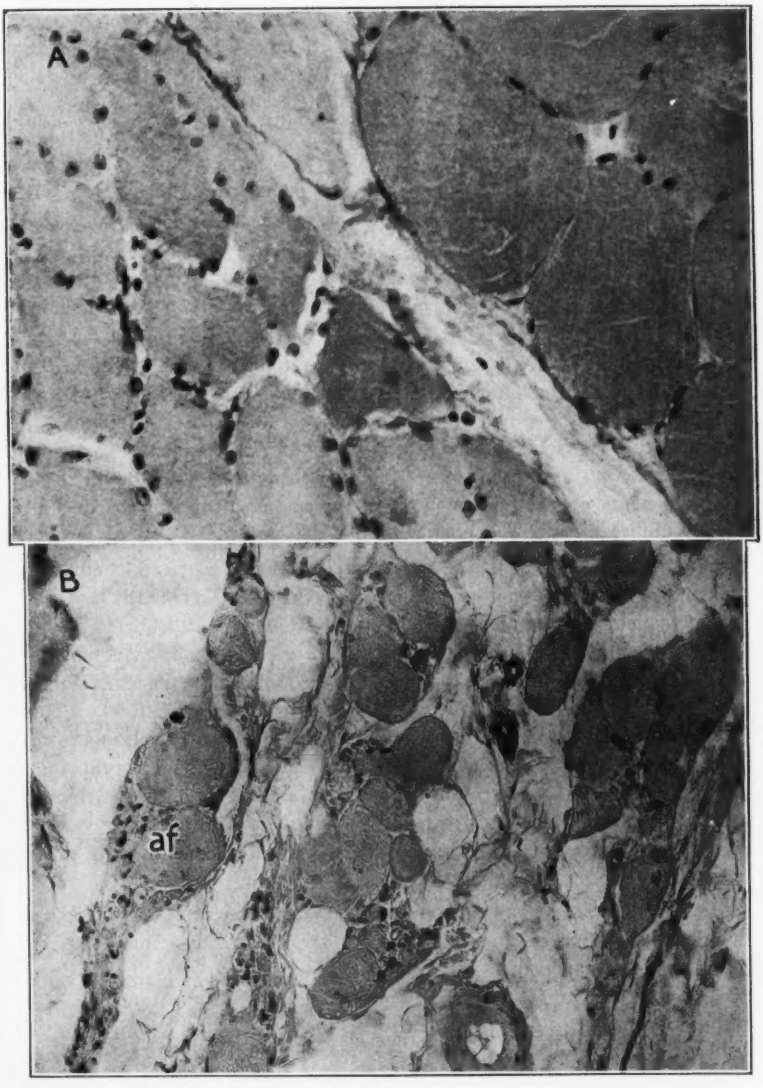

Fig. 3.—*A*, biopsy specimen from the tibialis anterior muscle of a man aged 63, with amyotrophic lateral sclerosis. Observe the enlarged nucleoli of the atrophic fibers. × 320. *B*, late stage of amyotrophic lateral sclerosis in a man aged 58; × 175.

a fundamental difference in this respect between progressive muscular dystrophy and the neurogenic types of atrophy. As a matter of fact, in muscular dystrophy, this migration of the nuclei is the most constant of all histologic changes, and it often happens that the nuclei form long rows in the interior of the muscle fiber. On the other hand, in amyotrophic lateral sclerosis and in other diseases in which the atrophy is due to pathologic changes in the lower motor neurons, this nuclear migration is exceptional and never attains such extreme degrees.

At first sight, the picture conveys the impression of an increased number of hypolemmal nuclei in the atrophic fibers. Slauck [2] contended that this feature was characteristic of "neurogenic" types of atrophy. A quantitative analysis performed according to an earlier published method [6] showed, however, that the increase in the number of nuclei in a not too advanced stage of atrophy is only apparent, and is due to a decrease in the diameter of the fibers, with a consequent denser arrangement of the nuclei (this phenomenon is most conspicuous in the longitudinal section). A longitudinal section from a case of advanced atrophy will show how the most atrophic fibers break down into fragments containing clusters of nuclei. It is difficult to exclude the possibility of nuclear division in the last-mentioned fibers.

As already mentioned, the drawings in figure 1 (*a* to *h*) represent typical changes. In spite of this, these pictures are evidence that one not infrequently encounters muscle fibers which are difficult to assign to any specific group of slightly atrophic, more atrophic or normal-sized fibers. Therefore, the picture obtained from histologic examination cannot be expected always to be schematically distinct. This variability is due to several factors: (*a*) The transverse sectional areas of the individual fibers of normal muscle are relatively different; (*b*) some fibers may have been distorted during excision of the biopsy specimen and (*c*) the progress of the atrophy will certainly not be entirely uniform in those fiber groups in which the atrophy is to be ascribed to one and the same neuron.

In cases of very advanced amyotrophic lateral sclerosis, the muscular changes are often less characteristic, but the picture may, nevertheless, still be presumptive of a "pathologic process, successively affecting lower motor neurons." The majority, if not all, of the muscle fibers are now atrophic. Fibers of various thicknesses are, however, still demonstrable in most of the primary muscle bundles. These fibers of varying thickness, however, are representative of different atrophic stages, namely, advanced and moderately atrophic phases. Not infrequently groups (generally small) of normal-sized or even hyper-

6. Wohlfart, G.: Eine neue Methode für quantitativ-histologische Studien an Skelettmuskeln, Ztschr. f. mikr.-anat. Forsch. **51**:471, 1942.

trophic fibers (fig. 3*B*) are encountered here and there in late stages also, and even a single normal-sized fiber per muscle bundle is by no means uncommon.

The interstitial connective tissue increases with advancing atrophy, and in the final stages it displays moderate infiltration with fat. This infiltration, however, is less pronounced than in muscular dystrophy, where it is often very conspicuous, even in moderately advanced cases.

The so-called muscle spindles (sensory structures) do not seem to be affected in amyotrophic lateral sclerosis. They survive and remain intact even in the late stages of the disease. The intramuscular nerve trunks often display changes of substantial diagnostic value. The coarser of the two kinds of fibers in these nerve trunks disappears, a phenomenon which can often be observed on inspection of such trunks as are available for examination.

Furthermore, it might also be mentioned that prolonged inactivity because of long confinement to bed, for example, may render the picture less distinct, for a diffuse and homogeneous atrophy of all the muscle fibers will then mask the typical changes to a variable degree.

MUSCULAR CHANGES IN INFANTILE SPINAL MUSCULAR ATROPHIES, NEURAL PROGRESSIVE MUSCULAR ATROPHY, POLYNEURITIS, SYRINGOMYELLIA AND POLIOMYELITIS

In the preceding section, the typical picture of amyotrophic lateral sclerosis was described as successive, disseminated neurogenic (motoneuronal) atrophy. This picture is not specific for amyotrophic lateral sclerosis, being seen in other ailments, the muscular picture of which I shall describe in more detail elsewhere.

Amyotonia congenita (Oppenheim's disease) and hereditary infantile spinal muscular atrophy (Hoffmann-Werdnig syndrome) are to all appearances identical and therefore may well be considered under the common designation infantile spinal muscular atrophy. Judging from biopsies I performed in 16 cases, infantile spinal muscular atrophy presents a characteristic picture. It is fundamentally a progressive, disseminated neurogenic atrophy, the appearance of which is to a certain extent modified by the fact that it generally occurs in children under 2 years of age (fig. 4). Karlström and Wohlfart [7] have given a detailed description of 7 cases of this disease. The addition of 9 cases to the material since the appearance of this publication [7] does not modify or change the conclusions drawn in their study.

Neural Progressive Muscular Atrophy (Charcot-Marie-Tooth Disease).—This disease, as is well known, is characterized by a high

7. Karlström, and Wohlfart, G.: Klinische und histopathologischen Studien über infantile spinale Muskelatrophie, Acta psychiat. et neurol. **14**: 453, 1939.

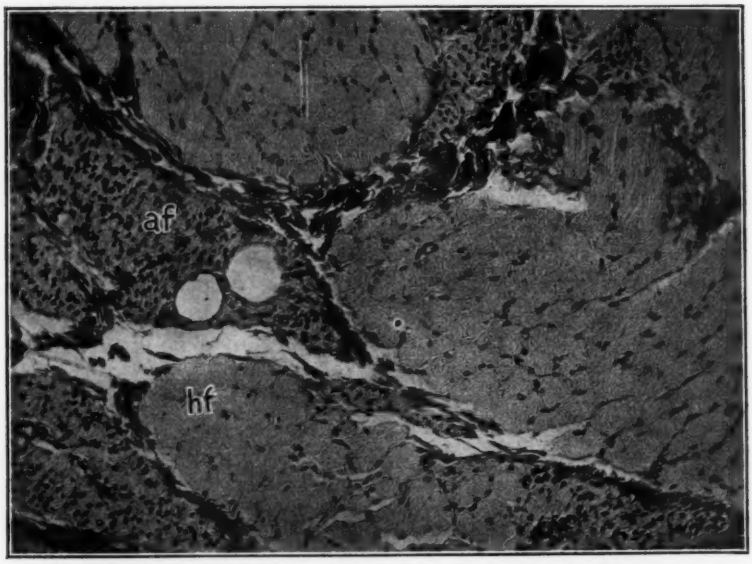

Fig. 4.—Biopsy specimen from the peroneus longus muscle of a girl aged 1 year 3 months with infantile spinal muscular atrophy; × 175. Atrophic fibers are indicated by *af;* hypertrophic fibers, by *hf.*

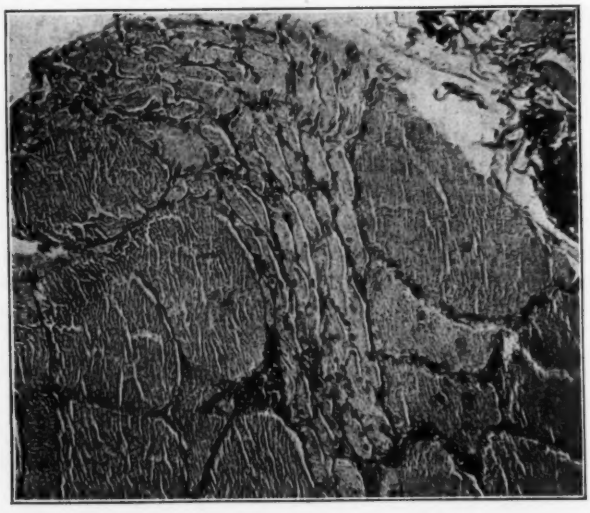

Fig. 5.—Biopsy specimen from the gastrocnemius muscle of a youth aged 18 with progressive neural muscular atrophy (Charcot-Marie-Tooth) disease, showing a group of atrophic fibers; × 150.

degree of muscular atrophy distally, in the extremities. This type of atrophy is generally considered secondary to changes in the nervous system. In their monograph on progressive muscular atrophy, Wohlfahrt and Wohlfart [8] described the same type of muscular changes as are characteristic of progressive muscular dystrophy. Since then, however, it has been revealed that 1 of the 2 cases described by them (which was examined only anatomically, not clinically) was probably one of myotonic dystrophy. The other case, published earlier by S. Wohlfahrt,[8] presented some atypical features. Davidenkow [9] would designate the condition in this muscular case as a so-called scapuloperoneal variant of neuropathic atrophy, the position of which is obscure. Therefore, one cannot attach too much importance to Wohlfahrt and Wohlfart's 2 cases of 1935. I shall discuss this question in a paper to be published in the near future. It is evident, however, that a typical disseminated neurogenic atrophy (fig. 5) often occurs in neural progressive muscular atrophy.

Polyneuritis.—Muscular atrophy occurring with various types of polyneuritis was studied by a number of authors toward the end of the nineteenth century. A complete review of the relevant early literature was given by Lorenz,[10] a survey of the later literature being available from von Meyenberg's [11] manual. Most authors, however, have described the muscular changes only incidentally, and very briefly. As a rule they state that the majority of the muscle fibers show atrophy and less distinct cross striation than do normal fibers. (Strümpell [12]; Vierordt [13]; Minkowski [14]; Debré, Lhermitte and Uhry [15]). Some authors observed no definite muscular changes (Déjerine [16]).

8. Wohlfahrt, S.: De l'amyotrophie progressive à type Charcot-Marie, Acta med. Scandinav. **63**:195, 1926.

9. Davidenkow, S.: Scapuloperoneal Amyotrophy, Arch. Neurol. & Psychiat. **41**:694 (April) 1939.

10. Lorenz: Die Muskelerkrankungen, in Nothnagel: Handbuch der speziellen Pathologie und Therapie innerer Krankheiten, Jena, G. Fischer, 1904, vol. 11, p. 3.

11. von Meyenberg: Die quer-gestreifte Muskulatur, in Henke, F., and Lubarsch, O.: Handbuch der speziellen pathologischen Anatomie und Histologie, Berlin, Julius Springer, 1929, vol. 9, p. 299.

12. Strümpell: Zur Kenntniss der multiplen degenerativen Neuritis, Arch. f. Psychiat. **14**:339, 1883.

13. Vierordt: Beitrag zur Studium der multiplen degenerativen Neuritis, Arch. f. Psychiat. **14**:678, 1883.

14. Minkowski: Beiträge zur Pathologie der multiplen Neuritis, Mitt. a. d. med. Klin. zu Königsberg, Leipzig, 1888, p. 59.

15. Debré, Lhermitte and Uhry: Les lésions anatomiques des paralysies diphtériques, Rev. neurol. **1**:206, 1934.

16. Déjerine, J.: Contribution a l'étude de la névrite alcoolique, Arch. de physiol. norm. et path. **19**:248, 1887.

The present material comprises specimens of muscle for biopsy from 24 clearly established cases of various types of polyneuritis, 2 cases of periarteritis nodosa with symptoms referable to the peripheral nerves and 4 cases of porphyria with paresis.

Muscular changes in polyneuritis are often of the successive, disseminated neurogenic type of atrophy, as is theoretically to be expected. Remarkably, in no fewer than 10 of the 24 cases of polyneuritis did biopsy reveal completely diffuse, homogeneous atrophy. In some other cases a combination of diffuse and disseminated neurogenic atrophy was present.

As histologic examination of peripheral nerve trunks in polyneuritis generally reveals a mixture of affected and apparently normal nerve fibers, the finding of completely diffuse muscular atrophy is difficult to explain. This phenomenon might well be due in some cases to prolonged confinement to bed in the early stages of the disease, with consequent more or less pronounced atrophy due to muscular inactivity, this muscular atrophy masking the disseminated neurogenic atrophy. As already mentioned, in patients who have been confined to bed a long time, completely diffuse and homogeneous atrophy is occasionally met with in cases of amyotrophic lateral sclerosis. In diphtheritic polyneuritis experimentally produced in guinea pigs,[17] a diffuse and homogeneous atrophy is also apparent in the paretic muscles, even though histologic examination of Marchi sections of the corresponding nerve trunks revealed only a few single degenerated nerve fibers. As inactivity could not play more than a subordinate role in these animal experiments, this diffuse atrophy must be attributed to other factors. Such factors might feasibly be sought in the toxic or infectious myopathy occurring concomitantly with the polyneuritis. Interstitial cellular infiltration, sometimes perivascular, is not infrequent in polyneuritic muscles. Of the 24 cases in the present material, such changes were exhibited in 9. These inflammatory changes in the muscle are quantitatively, however, of but slight degree, so that this explanation of the diffuse atrophy is not satisfactory either. Erb [18] had described such inflammatory changes in the muscles in cases of polyneuritis, and Senator,[19] Lorenz [10] and others suggested the designation "neuromyositis" for such cases.

A differential diagnostic factor of interest in polyneuritis is the presence of lesions of the sensory organs of muscle. The sensory elements of the muscle, which may be studied best by biopsy, are the

17. Wohlfart, G.: Om muskelförändringar vid polyneuriter, Nord. med. **34**: 988, 1947.

18. Erb: Zur Pathologie und pathologischen Anatomie peripherischer Paralysen, Arch. f. klin. Med. **5**:42, 1869.

19. Senator, cited by Lorenz.[10]

so-called muscle spindles. These organs, which are generally intact even in cases of far advanced amyotrophic lateral sclerosis, occasionally degenerate in polyneuritis, but not before a lapse of six months or longer after the commencement of the pathologic process. When the spindle is affected, its capsule becomes thick and the whole organ atrophies. To my knowledge, no investigations have been performed on human beings concerning the duration of time necessary for the total destruction of a muscle spindle. Many earlier authors [10] observed that the muscle spindles may be intact even in the presence of far advanced polyneuritis.

In the later stages of polyneuritis, the picture of the muscle is often complicated by the regeneration in process. Apparently, the reinnervation of the atrophic muscle fibers does not occur at a uniform rate in all the muscle fibers supplied by one and the same motor unit. This explains why the cross sectional picture of a muscle in an advanced stage of regeneration subsequent to polyneuritis exhibits muscle fibers of many different sizes but only here and there a motoneuronal grouping of the fibers.

In 1 of the 3 cases of the Guillain-Barré syndrome included in the present material, a few single hypertrophic muscle fibers, with a diameter of up to 150 microns, were observed. The occurrence of hypertrophic muscle fibers in polyneuritis was reported earlier by Gudden,[20] in a case of alcoholic polyneuritis.

The changes in muscle peculiar to periarteritis nodosa consist in part of the typical well known vascular changes and in part of muscular atrophy of the same type as that characteristic of polyneuritis.[21]

Syringomyelia.—Biopsies of muscles in 6 cases of syringomyelia showed as the most typical feature of this disease relatively large groups of extremely atrophic fibers (fig. 6). Pictures like this, which may suitably be termed "focal neurogenic muscular atrophy," are observable in other focal pathologic processes in the spinal cord, such as intramedullary tumors.[21] It is noteworthy, however, that in syringomyelia small groups of atrophic fibers are often discernible among the normal fibers.

Finally, it may briefly be mentioned that acute poliomyelitis gives a picture of disseminated neurogenic atrophy, very similar to that peculiar to the aforementioned types of disease. This disease will be discussed in detail in a later publication.

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20. Gudden: Klinische und anatomische Beiträge zur Kenntniss der multiplen Alkoholpolyneuritis, Arch. f. Psychiat. **28**:643, 1895.

21. Wohlfart, G.: Histo-Pathological Studies on Muscular Atrophy, Comp. rend. Cong. internat. de neurol. **3**:465, 1939.

MUSCULAR CHANGES ASSOCIATED WITH EXPERIMENTALLY PRODUCED ISCHEMIA IN THE SPINAL CORD OF RABBITS

Ever since the classic examinations of Stenon,[22] it has been known that compression of the aorta of a rabbit will cause paresis of its hindlegs. Vulpian [23] gave the correct explanation of Stenon's experiment. He asserted that the underlying cause must be an ischemic lesion of the spinal cord. Since Stenon's experiment, many authors have made histologic examinations of the spinal cord and have demonstrated the destruction of the nerve cells and the anterior roots of the spinal cord (for bibliography, see Rexed [24]).

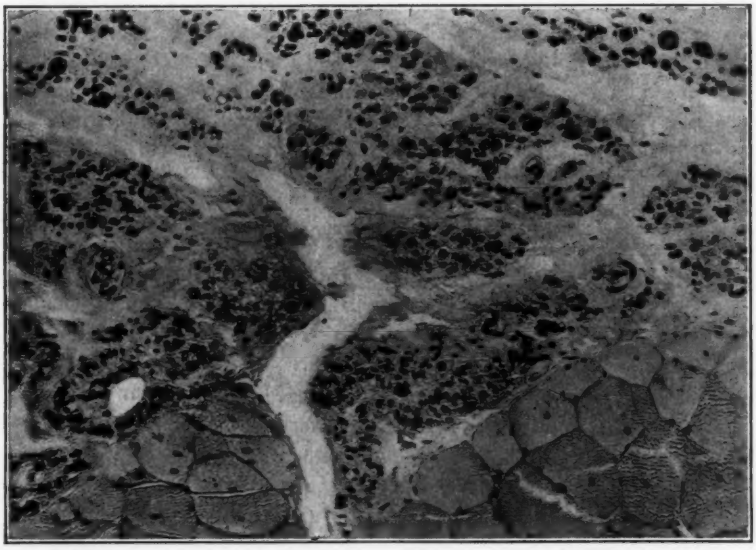

Fig. 6.—Biopsy specimen from the biceps brachii muscle of a man aged 34 with syringomyelia, showing focal neurogenic atrophy; × 175. Note the slight increase of "central" nuclei in the normal-sized fibers.

Häggqvist [25] showed that the large motor cells of the anterior horns are more susceptible to ischemia than are the smaller ones,

22. Stenon: Elementorum myologiae specimen, Amsterdam, E. Weyerstraet, 1669.

23. Vulpian: Leçons sur la physiologie générale et comparée du système nerveux, Paris, Germer-Baillière, 1866, p. 451.

24. Rexed, B.: Some Observations on the Effect of Compression of Short Duration of the Abdominal Aorta in the Rabbit, Acta psychiat. et neurol. **15**:365, 1940.

25. Häggqvist: A Contribution to the Question of the Nervous and Muscular Substratum of the Muscle Tone, Acta med. Scandinav. **104**:8, 1940.

and that one may by means of compression of the aorta of suitable duration (fifteen to twenty-five minutes) produce a rather selective degeneration of the coarser nerve fibers in the anterior roots below the level of the point of compression.

In accordance with the method suggested by Häggqvist, muscular changes have been produced in a rabbit, secondary to destruction chiefly of large nerve fibers within the ventral roots. The aorta of the experimental rabbit in question was compressed twenty minutes. A result of this compression was the occurrence of (spastic) paraplegia, which partially disappeared in the course of two weeks. The animal was killed at the end of seventeen days.

Microscopic examination of the musculus biceps femoris, which macroscopically revealed advanced atrophy, revealed the following picture: Intramuscular nerve trunks showed a considerable loss of large motor nerve fibers, whereas the muscle spindles appeared intact. The majority of the muscle fibers exhibited advanced atrophy. Here and there, however, were groups of normal-sized muscle fibers, mixed with atrophic fibers and in an arrangement similar to that occurring in disseminated neurogenic atrophy in man (fig. 7). Of special interest was the fact that one could see isolated normal-sized, slightly hypertrophic or slightly atrophic muscle fibers scattered everywhere among the atrophic fibers and appearing in regular distribution in the transverse sectional area of the muscle (fig. 7). The arrangement of these fibers showed that they were the so-called b muscle fibers.[26] The significance of this observation will be discussed later in this paper.

COMMENT, WITH PARTICULAR REFERENCE TO ANATOMY OF MOTOR UNITS

In spite of numerous publications on the innervation of the skeletal muscles, knowledge in this sphere is still indefinite. It is therefore a delicate task to discuss the nature of the muscle picture in those diseases in which muscular atrophy occurs secondarily to pathologic changes in the lower motor neurons. On the other hand, however, the aforedescribed, typical changes in the muscles of patients with such diseases may throw new light on the arrangement of the muscle fibers in the motor units.

As pointed out earlier in this paper, a motor unit is considered to consist of muscle fibers innervated by one and the same motor cell of the anterior horn of the spinal cord and to all appearances constitutes a functional and trophic unit. The size of motor units will presumably vary in different muscles, the units in the ocular muscles and in the small muscles of the hand, for example, being relatively small. Motor

26. Wohlfart, G.: Ueber das Vorkommen verschiedener Arten von Muskelfasern in der Skelettmuskulatur, Acta psychiat. et neurol., 1937, supp. 12, p. 1.

units of various sizes are also probably existent in one and the same muscle, their arrangement presumably being determined by some law of nature. Of recent years, electromyographic studies have led to increased knowledge of the manner in which motor units function. It should be borne in mind, however, that the designation "motor units," as conceived by electromyographists, has by no means been proved to be synonymous with the term as used by anatomists; this fact was pointed out, *inter alia,* by Kugelberg and Skoglund.[27]

According to calculations, individual motor units comprise from one to several hundred muscle fibers. In a theoretic calculation in man, Lindhard[28] concluded that the number was 275, while Clark[29]

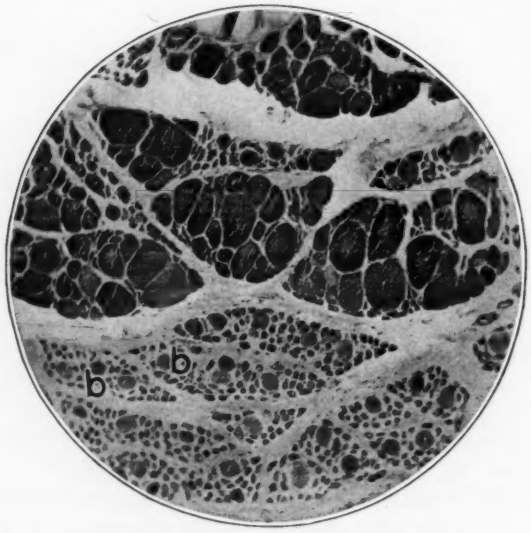

Fig. 7.—Section from the biceps femoris muscle of a rabbit with experimentally produced ischemia of the spinal cord, showing disseminated neurogenic atrophy. In the lower part of the field, the b muscle fibers (*b*) are distinguishable, because they are only slightly atrophic, while the others are in a state of advanced atrophy. Häggqvist's iron hematoxylin stain; × 110.

calculated the number of muscle fibers in a motor unit as 120 to 165 in certain muscles of the extremities in cats. Figures of a similar order

27. Kugelberg, E., and Skoglund, C. R.: Natural and Artificial Activation of Motor Units: A Comparison, J. Neurophysiol. **9**: 399, 1946.

28. Lindhard: Der Skelettmuskel und seine Funktion, Ergebn. d. Physiol. **33**: 337, 1931.

29. Clark, D. A.: Muscle Counts of Motor Units: A Study in Innervation Ratios, Am. J. Physiol. **96**:296, 1931.

have been obtained by calculating the relation of the number of motor nerve fibers to the number of muscle fibers of individual muscles.[29] It should be borne in mind that these counts are mean values; there is nothing to prevent a few single units from consisting of but a small number of fibers, or possibly even of but one.

Nothing definite is known concerning the intramuscular arrangement of the muscle fibers in a motor unit. One is tempted to assume some kind of correlation between the appearance of groups of atrophic muscle fibers in such diseases as produce progressive destruction of lower motor neurons, on the one hand, and the arrangement of the motor units, on the other. As already pointed out, however, these groups generally consist of ten to fifty atrophic fibers. The number of fibers per individual group is thus considerably smaller than the calculated number of fibers in a motor unit. It must therefore be borne in mind that the transverse sectional area of a motor unit might possibly correspond to several atrophic groups. Only by continued studies, especially studies on innervation, can it be decided whether this is the case.

That the groups of atrophic fibers appearing in amyotrophic lateral sclerosis and in the other diseases discussed in this paper must at any rate constitute parts of motor units is to be considered as established. The synchronous atrophy of fibers in one and the same group cannot well be attributed to anything but an assumed lesion of the common innervation.

In many muscles, both in animals and in man, the muscle fibers do not extend along the whole length of the muscle. In the sartorius muscle in man, for example, the average length of the muscle fibers is only about one-eighth that of the muscle.

In 1935, Wohlfahrt and Wohlfart [8] had mooted the possibility of the motor units consisting of groups of muscle fibers arranged successively in the longitudinal direction of the muscle. Observations made by Cooper [30] argued in favor of this supposition.

The results of the present investigation justify one in concluding that the motor units lie intermingled, or at least encroach on one another's territory. This applies to the atrophic groups of fibers in the types of atrophy discussed here, which, as has been pointed out, must constitute at least parts of the motor units. Now and then, however, a well outlined group of atrophic fibers is encountered (fig. 5).

Earlier in this paper it was pointed out that the normal-sized fibers which are to be seen in the later stages of amyotrophic lateral sclerosis are arranged in groups similar to those of the atrophic fibers in earlier stages. The number of normal-sized, or sometimes hyper-

30. Cooper, S.: The Relation of Active to Inactive Fibres in Fractional Contraction of Muscle, J. Physiol. **67**:1, 1929.

trophic, fibers in these groups seems on an average to be less than in the atrophic groups of fibers. This may be presumptive evidence that in the early stages of the disease it is mainly the larger motor units that are destroyed, whereas in the advanced stages of the illness the small units are also destroyed.

It seems therefore that in amyotrophic lateral sclerosis and in other diseases with progressive degeneration of lower motor neurons the muscle picture might permit the conclusion that both large and small motor units are distributed according to natural laws over the transverse sectional area of the muscle. A primary muscle bundle probably comprises parts of at least one large and one small motor unit. From a physiologic point of view, this possibility may be of interest in explaining the graduation of muscular contraction.

As mentioned in the preceding paragraph, otherwise completely atrophic primary bundles may in advanced cases contain one or a few normal-sized or slightly atrophic fibers. In view of this fact, the possibility of individual motor units consisting of only one or a few muscle fibers cannot be rejected. One must, of course, also assume that a motor unit may consist of such isolated fibers localized to several primary bundles.

One might, above all, assume that the so-called b muscle fibers,[26] of which one or more per muscle bundle exist in all normal muscles, are each innervated by its particular nerve fiber. As the b fiber system does not seem to be well known in the literature of the United States, a typical photograph of these fibers in the sartorius muscle of a 4 month old child is given (fig. 8). These b fibers develop earlier embryonically than the other muscle fibers, and even as late as the first months of life they may be detected in most of the muscles because of their larger size. Certain small structural differences are also observable at this stage. Later, the growth of the other muscle fibers catches up with that of the b fibers, so that the latter are then normally seldom discernible. In the external muscles of the eye they are generally detectable, however, owing to structural differences.[31] Under certain pathologic conditions, b fibers often become apparent again, because in atrophy due to inactivity they may atrophy more slowly than do other fibers.[26] Knowledge of this normal fiber system is, of course, of great importance in judging pathologic muscle pictures, e. g., that of amyotrophic lateral sclerosis. In this disease b fibers not infrequently survive in otherwise atrophic parts of the muscle, although they also atrophy with time.

31. Wohlfart, G.: Zur Kenntnis der Altersveränderungen der Augenmuskeln, Ztschr. f. mikr.-anat. Forsch. **44**:33, 1938.

It was mentioned earlier that b muscle fibers did not atrophy to the same extent as did the other fibers in ischemia experimentally produced in the spinal cord of a rabbit (compare figures 7 and 8).

The ventral roots of the spinal cord comprise nerve fibers of two sizes.[32] The small nerve fibers consist mainly of preganglionic sympathetic fibers. Small fibers are, however, to be found also in those parts of the spinal cord through which the preganglionic fibers do not extend. Eccles and Sherrington [32b] showed that nerves to muscle contain both coarse and fine nerve fibers after deafferentiation also,

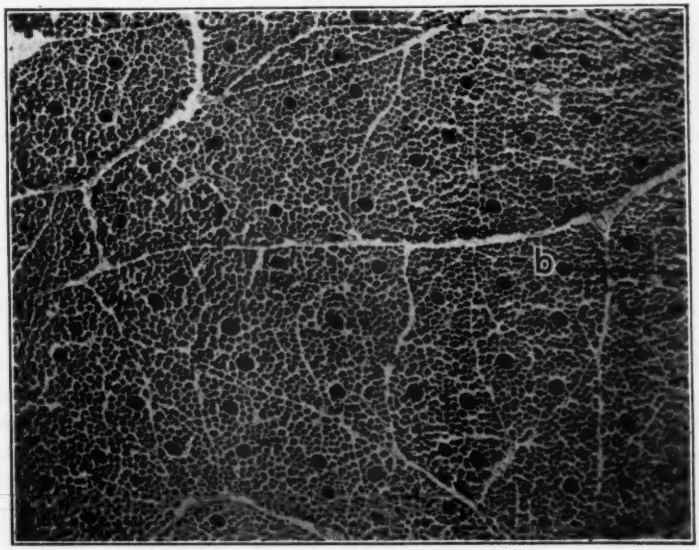

Fig. 8.—Section from the sartorius muscle of a 4 month old child, showing a normal picture. The b fibers (*b*) are readily visible on account of their considerably larger diameter. Häggqvist's iron hematoxylin stain; × 80. After Wohlfart.[26]

so that both types of fibers are presumably efferent. The coarse nerve fibers undeniably extend to the muscle fibers, where they form motor

32. (*a*) Kiss, and Mihálik: Ueber die Zusammensetzung der peripheren Nerven, Ztschr. f. Anat. u. Entwcklngsgesch. **88:** 112, 1928. (*b*) Eccles, J. C., and Sherrington, C. S.: Numbers and Contraction-Values of Individual Motor Units, Proc. Roy. Soc. London, s. B **106:**326, 1930. (*c*) Häggqvist: Zur Kenntnis einer doppelten zerebrospinalen Innervation der Skelettmuskeln, Ztschr. f. mikr.-anat. Forsch. **43:** 491, 1938. (*d*) Swensson, Å.: Ueber die Kaliberverhältnisse in den vorderen Rückenmarkswurzeln beim Menschen, ibid. **44:** 187, 1938. (*e*) Rexed, B.: Contributions to the Knowledge of the Post-Natal Development of the Peripheral Nervous System in Man, Acta psychiat. et neurol., 1944, supp. 33, p. 1.

end plates. The destination of the fine nerve fibers, however, is more obscure. O'Leary, Heinbecker and Bishop [33] suggested that the fine nerve fibers might be motor fibers pertinent to the muscle spindles. This is to a certain extent correct. The number of spindles per muscle, however, is rather small, for which reason it is not very probable that the rather numerous small nerve fibers existing in every motor nerve should be assigned exclusively to the muscle spindles. In addition, it is well known that fine myelinated, as well as nonmyelinated, nerve fibers may terminate in ordinary muscle fibers with exceptionally small end plates, sometimes terminating even in the same muscle fibers as do coarse nerve fibers with ordinary end plates. One must, therefore, be justified in assuming that some of the fine nerve fibers have another purpose. Häggqvist [32c] suggested that the fine nerve fibers might be intended to serve muscle tonus. On stimulating the fine nerve fibers after blocking the coarser ones, Leksell [34] could not, however, produce any motor effect.

In amyotrophic lateral sclerosis, it appears that the pathologic process in the ventral roots has a predilection for the coarse nerve fibers, whereas the fine nerve fibers are allowed to survive.[35] This applies also to the intramuscular nerve trunks. This observation is in conformity with the fact that the muscle spindles remain intact even in advanced stages of the disease. If, as was thought by Eccles and Sherrington, the fine nerve fibers innervate small motor units and the coarse nerve fibers larger units, this innervation might feasibly be accepted as an explanation why the smaller units seem to atrophy later than the larger ones. The fact, however, that the smaller units do atrophy in the end, in spite of an apparent intact condition of the fine nerve fibers, contradicts this theory. One might quite as well imagine a differentiation in the category of coarse fibers, the coarser fibers being attacked by the pathologic process earlier than the less coarse ones.

The innervation and the purpose of the b fibers are still obscure. Judging from the experiment on the rabbit previously cited, one might conclude that b fibers are innervated by small motor nerve fibers, since seventeen days after the destruction of a great number of substantially coarse fibers the b fibers had survived completely, or were but slightly

33. O'Leary, J.; Heinbecker, P., and Bishop, G. H.: Analysis of Function of Nerve to Muscle, Am. J. Physiol. **110**:636, 1935.

34. Leksell: The Action Potential and the Excitatory Effects of the Small Ventral Root Fibres to Skeletal Muscle, Acta physiol. Scandinav. (supp. 31) **10**:1, 1945.

35. Wohlfart, G., and Swank, R.: Pathology of Amyotrophic Lateral Sclerosis: Fibre Analysis of the Ventral Roots and Pyramidal Tracts of the Spinal Cord, Arch. Neurol. & Psychiat. **46**:783 (Dec.) 1941.

atrophic. On the other hand, experience with amyotrophic lateral sclerosis shows that these muscle fibers generally atrophy, despite the fact that the fine-calibered motor nerve fiber system is probably intact in the disease in question. This problem must therefore be studied further.

Since histologic evidence supports the assumption that at least certain muscle fibers may be innervated by both fine and coarse motor nerve fibers, it should be borne in mind that such double-innervated fibers should atrophy more slowly than other fibers in a number of pathologic conditions.

SUMMARY

The microscopic picture of muscular atrophy secondary to pathologic changes in lower motor neurons is described in detail. The material comprised specimens of muscle from 46 cases of amyotrophic lateral sclerosis, in 2 of which autopsy was performed; 8 cases of progressive neural muscular atrophy; 24 cases of polyneuritis; 2 cases of periarteritis nodosa, in 1 of which autopsy was done; 4 cases of porphyria, and 6 cases of syringomyelia, 1 with autopsy. Furthermore, a muscle was examined from a rabbit in which ischemic changes in the spinal cord had been artificially produced. The muscle material from cases of acute poliomyelitis has been reserved for a later report. Certain results, however, are incidentally mentioned.

Biopsy of muscle is of definite value for the establishment of the diagnosis of the aforementioned diseases.

In muscular atrophy due to successive destruction of individual lower motor neurons, the muscle picture exhibits certain characteristics. In such a case biopsy often produces conclusive evidence for the diagnosis of "successive, disseminated neurogenic muscular atrophy." This type of disease is characterized by the atrophy of fibers in groups, a number of which are visible in a transverse section of the muscle. The fibers of one and the same group exhibit the same degree of atrophy, but the groups show different stages of atrophy. The arrangement and appearance of the muscle fibers in these groups, as well as their relation to their environment, is described in detail.

Amyotrophic lateral sclerosis is characterized by successive, disseminated neurogenic atrophy. In patients confined to bed a long time diffuse muscular atrophy due to muscular inactivity may blur the picture.

In infantile spinal muscular atrophy (Oppenheim and Hoffmann-Werdnig diseases), muscular atrophy is also of the successive, disseminated neurogenic type, though modified, as the condition usually occurs in children. In this disease certain groups of fibers are obviously hypertrophic.

Progressive neural muscular atrophy (Charcot-Marie-Tooth disease) is also often characterized by successive, disseminated neurogenic atrophy.

Polyneuritis is characterized either by complete diffuse and uniform atrophy or by progressive, disseminated neurogenic atrophy or by a combination of the two types. Besides this, interstitial cellular infiltration of the muscle is often perceptible.

In syringomyelia changes of focal neurogenic type, i. e., relatively large groups of highly atrophied fibers enclosed by zones of normal muscular tissue, occur. Moreover, a picture characteristic of disseminated neurogenic atrophy is often encountered.

The muscular atrophy in acute poliomyelitis (Heine-Medin disease) is fundamentally of the simultaneously occurring, disseminated neurogenic type and displays groups of approximately equally atrophied fibers. In regeneration the picture is modified considerably; this phenomenon will be dealt with in a special publication.

By artificially induced transient ischemia of the spinal cord of a rabbit (Stenon's experiment), muscular atrophy secondary to a relatively selective destruction of the large fibers in the ventral roots was produced. Muscular atrophy was in this case of the same type as in simultaneous, disseminated neurogenic atrophy in man.

The arrangement of the muscle fibers in the motor units is discussed.

In all normal musculature there is a special system of muscle fibers (b fibers). These must not be considered pathologically changed muscle fibers when they are encountered in the aforementioned or in other kinds of muscular atrophy.

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THE SUPERIORITY ATTITUDE AND RIGIDITY OF IDEAS

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THE SUPERIORITY and the inferiority complexes are no longer fashionable terms in psychiatric literature. The former has never received more than scanty mention and indirect reference; the latter has become trite and threadbare. The inferiority complex has also had to share the unpopularity of the Adlerian theory. This, however, with its restricted concept of organic defects, ignores the broader ideational types of personality inadequacy feelings. The importance of these feelings, even to orthodox psychoanalytic thought, is apparent when one considers that the frustrations which they imply must often be the critical points of obstruction to the libido from which occur the all-important regressions to infantile gratifications. Indeed, the castration complex clearly presents the sexual aspect of the inferiority feeling.

The emphasis on psychic traumas and mechanisms has perhaps led to neglect of the special types of personality organizations which often determine the patterns of psychoneurotic reactions. Here trends toward feelings of inferiority and superiority have an importance comparable to that of introversion and extroversion.

Inferiority and superiority feelings probably do not represent simply two opposite poles of manifestations of the same order. Inferiority feelings tend to be episodic, or at least variably accentuated according to the impact of circumstances. They are often traceable to environmental factors, are usually readily discerned and are subject to good therapeutic adjustment. In contrast, the superiority feeling has a striking, lifelong uniformity independent of experience. It is usually subtly manifested and colors the personality diffusely with a depth and fixity that are likely to defeat therapy. It gives the impression of a congenital quality, so firmly established at the very basis of behavior that it would seem better to speak of it as a superiority type than as an isolated complex.

An attempt will be made to delineate the characteristics of this type and the manner in which they produce psychiatric disturbances. It is stressed that such a description can be only a composite one since all the manifestations are hardly to be found in any one person. Likewise, for the sake of clear definition, traits that may be only relative and partial will be described as though they were complete and absolute.

The superiority feeling is rarely frankly expressed, and its revelation comes usually as a surprise to the investigator. Such superficial manifestations as arrogance, self assertiveness and vanity are the well recognized mask which inferiority uses to deceive both itself and the world. The person with the superiority feeling needs no such deception, feels no call for perpetual reassurance. He rests secure in a tacit, unquestioning acceptance of his own worth and is not dependent on outside recognition. In point of fact, he is often above the average according to popular standards of ability and character. At work he is industrious, accurate and efficient, although he is likely to be a routinist because he lacks the drive of discontent. He adheres strictly to a code in which all the distinctions between right and wrong are clearcut. He is neat and precise, and, if he is often stingy, it is because it is as impossible for him to be careless or unplanful in money matters as in anything else.[1] These virtues are not the result of an effort to excel or to establish a sense of personal worth; that would be a compensation for an inferiority feeling. On the contrary, the perfectionist self estimate is primary, and anything inconsistent with it is automatically impossible (case 4—"M. is not the sort of boy who does such things").

This perfectionism is the essential defect of the superiority complex. True worth is achieved oftenest by those who have been goaded or humbled by self dissatisfaction. Augustine and Loyola established their piety on the realization that they had been sinners, and out of the humility of St. Francis arose the "Canticle of the Sun." But the person with the feeling of superiority, viewing his own faultlessness, is unable to understand and sympathize with human frailty. He cannot extenuate the failings of others without diminishing the value of his own integrity. Thus, his lack of kindliness may amount almost to an inhuman quality. His self content frees him from the urge to irregularities of more restless souls. Such persons are austerely self contained; they are the Malvolios of life, who think that because they are virtuous there shall be no more cakes and ale. This is reflected in the poverty of their social contacts. The essentials for friendship are deficient—the ability to give, which would require sympathy for another's lack, and the ability to need, which would impugn their self sufficiency. In social groups they stand apart, impatient of levity and repelled by a little good, coarse fun. They feel themselves to be outsiders, not enviously, as do those with the feeling of inferiority, but somewhat pridefully. For their impeccability they are admired, but they are seldom liked. Virtue, like everything else, can be overdone.

1. It is obvious that these characteristics are the same as those of the anal-erotic type of the school of psychoanalysis.

RIGIDITY

Any brief definition of rigidity must be an oversimplification. One may think of it as a limitation or a one-wayedness of the perception of values and of cause-effect relationships that does not admit of compromise or gradation. Superiority and rigidity are reciprocal corollaries so exquisitely mingled that it is possible that the one does not exist except in relation to the other. Thus, to the extent that the person with a superior feeling thinks himself above criticism, he must consider his ideas and motivations above criticism and—more important—above the need of modification. Moreover, any deviation from them is not to be tolerated. But there is another aspect. The emotional gratification of the person with the superiority attitude, satisfying though it may be, is nevertheless a poor and narrow one, since it is expended at only one shrine—himself. This is a tenuous security that must be protected strictly; any implication or doubt that would topple the idol would be a psychologic catastrophe. To shift the figure rather violently, one who carries all his emotional eggs in one basket must walk rigidly to avoid the slightest jolt. A person rarely manifests a universal feeling of superiority. The feeling is usually limited to a few definite spheres, such as physical, moral or intellectual distinction, business ability or social worth. However, in whatever sphere it may be present, it must be maintained with an all or nothing absolutism, or inviolability. The "superior" person gets into psychiatric trouble only when the feeling cannot thus be maintained in contact with reality. It is, indeed, his peculiar vulnerability that he cannot endure imperfections. Here he is in vivid contrast to the man with the feeling of inferiority, who does not expect too much of himself and who therefore can receive a blow to his self esteem with considerable resilience. For the person with the superiority attitude, such a blow would be an unendurable psychic trauma. Against any possibility thereof he seeks the protective security of strict adherence to uncompromising attitudes, narrow and clearly defined rules of behavior and a code of black and white opinionations. In these, there are none of the softer tones of understanding that might permit him to condone in himself or in others the traits that fall short of his ideals.

A feature of this striving for security in one's self estimation is the tendency to retreat from the acceptance of a world of shifting and ill defined values and to immure one's self in an ideational cosmology that will afford absolute stability. This absolutism has long been known to be characteristic of the obsessive thought pattern. But absolutism in this reference is only fractionally indicative of the extent of the rigidity formulations, which in extreme cases may involve areas of such universality that philosophic, and even mystic, aspects are apparent, often with

superstitious and magical trends. In this connection, it must be kept in mind that a concept of a high degree of fixity of cause-effect relationships is necessary to maintain the feeling of security that is so essential to the "superior" person.[2] Here the peradventure of chance must not be granted any degree of potency. This is often seen in the compulsive ritual, where one may discover a device that symbolically destroys the faintest possibliity of a dreaded mishap. Ordinary persons accept the fact that unforeseeable variables may alter an expected result. They do not plan too closely and are not too much disturbed by manifestations of chance or "luck," over which they cannot have much control. But the person with the rigid-superior pattern cannot accept unpredictability in his scheme of things. He can find repose only in the assurance that the universe is well ordered with influences that are fixed and perceptible. (Compare Dr. Pangloss' "best of all possible worlds" in Voltaire's "Candide.") To fill this need, he tends to become addicted to superstitious formulas which will fix the course of events and to ritualistic thoughts and actions which will eliminate uncertainties. As part of this tendency, ideas of potency of thought in influencing phenomena may reach the development of a metaphysical system.

There is a close parallel in the thinking of primitive man.[3] Here, too, there is an inability to accept phenomena as fortuitous, or, rather, as the resultants of the interplay of innumerable, incalculable forces. For the savage there was no comprehension of nature and its laws. His actual observation of the cause of things was limited to those changes in which a living agency was concerned. Thus it followed that when the cause of an event was not directly apparent it was ascribed to unseen living agencies—spirits, gods and demons. His "science" therefore explained phenomena by personalizing them, formulated superstitious theories of animate influences and countered to control these

2. This requirement for stability is illustrated concretely by the distress occasioned one such patient by the conditions at his place of employment. This was described as a large industrial firm in which everyone was seeking advancement to someone else's job. It was a little world of wire pulling, favoritism seeking, derogation, underhand competition and deceit, leading to a constant turnover of preferments and displacements. For the patient, limited by his unrealistic and personalized attitude that success was to be attained only by ability and effort, this milieu of chaotic instability, with its crazily tangled cause-effect relationships, was gravely disquieting because it deprived him of the security of a basis on which his effort could have any certainty of effectiveness.

In contrast, a person of opposite type, not so imbued with the importance of his own industry, might even welcome such instability as supplying a constant flux of circumstances from which he might sometime chance to pluck a favorable opportunity.

3. (*a*) Freud, S.: Totem and Taboo, translated by A. A. Brill, New York, Moffat, Yard & Co., 1918. (*b*) Frazer, J. G.: The Golden Bough, New York, The Macmillan Company, 1925.

influences by rituals and magic. Similarly, rigidity, with its narrowed perceptions, personalizes mischance and failure too completely, does not recognize uncontrollable circumstances (which might absolve one from blame) and ignores incalculable variables. In mimicry of the primitive, it requires a world of relatively simple and predictable cause-effect relationships as the basic security for exact planning and for fixed estimation of values as to what is good or evil, desirable or undesirable, healthful or unhealthful. It cannot tolerate the infinite, unknowable factors which might disturb such a relation, and which we speak of loosely as "chance." When such factors cannot be ignored, the person with the rigid-superior pattern is likely to react by a ritualism which will neutralize them. Here, ritualism must be understood to include stereotyped thought and action sequences that are invested with the power favorably to fix the course of events. (By extension, it may also become a mechanism of expiation, i. e., by taking an accomplished event as if it had never happened.)

Tendencies to such reactions as momentary and purely episodic evidences of our heritage of latent superstition are recognizable in all of us; it is only under the stress of the inability to face reality's threat to the self image, as accentuated by the need for perfect security, that they come to dominate the mental life in the form of obsessions and compulsions. Here the reversion to primitive thought patterns is real. The psychic mechanisms that symbolically avert a danger, assure success or expiate a sin mirror exactly the magic by which an enemy is destroyed, the ritual that furthers a favorable event or the sacrifice or ablution that removes the burden of guilt. This device of relief through symbols will be discussed later.[4]

Freud [3a] has pointed out that the magic rituals were derived fundamentally from the universal primitive tendency to overvalue the power of thought. Magic became the device to "step up" and to give direction to this power. Vestiges are to be found everywhere of this belief that

4. Many primitive thought patterns are seen as fragments in normal life. The fear of being cursed illustrates the inherent belief in the potency of thought. One's own unpropitious thoughts must be neutralized by a "God forbid" or by crossing one's self. Plans that may be too optimistic—thereby inviting a malevolent influence—must be guarded by a meek "God willing" or by various rituals, such as touching wood. Christian science capitalizes a conception of remote thought influence, to which it counters its religious white magic.

Among aviators, men who follow a vocation in which insecurity is extreme and in which the forces that might mediate a catastrophe are to the highest degree multiform, unpredictable and unavoidable, a bewildering maze of superstitions, rituals and fetishisms has been constructed as protection against misfortune. Especially significant is the semicomic gremlin who, as a frank personification of the unknown cause of mischance, is the spiritual brother of the mischievous gnome and leprechaun.

if one thinks in a certain way things will be influenced to happen that way. This idea is vivid in Christian science—a belief that in many other respects shows the superiority-rigidity pattern. (The reverse belief—that things will happen in a way the opposite of what is planned —belongs to a different category, since it implies the intervention of a malevolent spirit.) This concept also has its origin in the animistic orientation of the primitive mind. Just as the thought or will of the gods or demons was causal to every event, man, likewise capable of thinking or willing, must possess some portion of this power. This became more likely to the extent that man identified himself with the gods as being created in their image, or as being descended from them, or as being specially favored by them. This is evidenced by the fact that, in most cultures, this power was strongest in kings and priests. Since it was known that one's enemies constantly wished one ill, it was natural to conclude, in accordance with the notion of the potency of thought, that when a catastrophe did occur the baneful wish was the cause of it. It is immaterial whether the thought was capable of acting directly or whether it gained effectiveness through magic or the intervention of a spirit. That a direct influence was possible is indicated by the many variants of the evil eye superstition that persist to this day. From the possibility of affecting another by the potency of thought, it was an easy step to the belief that one could, similarly, alter events and sway destiny to one's liking. By extension, this gave rise to the metaphysical system which asserted that whatever happened in the universe had already preexisted in the mind of man. The mystic notion penetrated early Greek philosophy that the microcosm mirrored the macrocosm, and there arose the formula that "man is the measure of all things." It is not surprising that this ubiquitous idea should become the device by which one, by thinking a certain way, might attempt to produce a desired result, and thus introduce a controlling agency against untoward happening. The primitive conception of phenomena as the result of directive will, since it does away completely with chance as a factor, is peculiarly adapted to the needs of rigidity. The person with the rigid-superior pattern cannot accept chance and fallibility as normal and unavoidable and sees an adverse personal implication in mischance and error. He overvalues them as blows to his prestige and must avoid them. In ordinary behavior he tends to restrict action to those things in which he can foresee success, hesitates at chance and change and misses the educational value of failure, which is the stimulus it gives to the search for better methods. At the pathologic level, however, he may be forced to retreat into a cosmology in which primitive thought patterns involving ideas of the potency of thought and symbolic and ritual influences are invoked to protect his security.

It may be summarized that rigidity is basically protective in that it serves to establish a concept of values so fixed and of cause-effect relations so oversimplified as to afford a milieu of complete predictability in motivating one's actions and of complete stability in one's self esteem. In accomplishing this, it may have to restore to dominant activity primitive modes of thought that are normally present only as vestigial superstitions.

Symptoms arise only when the ordinary protection of rigidity does not suffice against the onslaught of reality. Anxiety is the simplest result of this loss of security, although it may be quickly obscured by a retreat into more complicated mechanisms. Perfectionism is vulnerable to many traumas. A present fault or a long-buried guilt complex may be so out of harmony with the self image as to inflict a grievous wound on it. This guilt is often purely ideational, since, in accordance with a belief in the potency of thought, a baneful wish has a significance almost equal to that of the crime which would fulfil it. Thus Freud [3a] stated:

> A compulsive neurotic may be oppressed with a sense of guilt that is appropriate to a wholesale murder. . . . And yet this sense of guilt is justified: it is based upon . . . death wishes . . . toward his fellow beings.

In other cases the fault may be merely a deviation from an ideal of character so exalted as to be impossible to maintain (case 2). Again, the turn of events may force on one the fact that the eternal verities are not always reliable, that good is not always rewarded or evil punished, that well planned or well intended actions may miscarry and that industry and competence do not always insure success and security. The collapse of such naïve formulas may be disastrous to one so rigidly committed to his all-or-nothingness that he cannot compromise to a new adjustment.

CASE 1.—The study of this extremely complicated case has not yet been completed, and only a portion of the data will be presented to illustrate the feeling of superiority (here strongly restricted to a single field), the extremity of the effort to protect it against the minutest infringement and the absolutism of the requirements for its protection. There will be no attempt to discuss the basic factors which, by threatening the superiority, have occasioned the intense concern over it and the effort to guarantee its security. To increase its evidential value, most of what follows was gleaned as separate items directly from the case record with the minimum of editing. This will explain its disjointed and miscellaneous character. Comments are indicated by parentheses.

E. C. H., a veteran aged 22, suffered from an obsessive belief that he was insane, or soon to become so. This had existed for one to two years, having gradually been superimposed on an anxious depressive state of similar content. Indeed, the difficulty in concentrating and the "clouding" common in anxiety states were among the evidences of the alleged insanity.

His mental equipment was unusual. Since early high school days he had had one consuming interest to which all else was subsidiary—mathematics. (It will be seen that he had no mean estimate of his ability. It was ascertained from outside sources that he really had a very unusual talent, perhaps genius, in this

subject.) In contrast, his attainment in other fields, particularly in language usage, was almost pathologically defective. His inarticulateness was a considerable handicap to the study. He accepted these disabilities placidly. His disinterest in other things was so complete that it was evident that his fear of insanity was essentially (at the conscious level) a fear of lost proficiency in his beloved study.

In childhood he did not mix very well. "They did not like me; my personality was not agreeable to them." At 13 he became conscious of a mathematical ability incomparably superior to that of his classmates. Everything else now became insignificant, "whether others got better marks, had higher general intelligence or more material things; I knew where my abilities lay." He became impatient of any imperfections in his knowledge. Within a year or two "the only competition was with the teacher." Regarding a course in advanced algebra that he was taking at the time, he stated, "I have already taught this subject, and the only purpose now is to seek perfection, which would mean the elimination of all possibility of error with good arrangement in textbook style." He daydreamed of being the "greatest mathematician." He repeatedly referred to his superior mental endowment. "The only thing important to me was my mind, and my chief effort was to protect it from harm. I began certain habits of sleeping on my right side, definite hours of sleeping, controlled eating and exercise." At that time he thought of his mind as a perfect organism, which he could not conceive of as going insane. However, he sought to overcome all factors which might impair his mentality. He had left a job in which he handled metallic lead because he thought lead poisoning might affect his brain. He had worked in a garage one summer and worried about the effects of gasoline fumes. He feared that hanging head downward in gymnasium class would injure his brain and found a pretext to be excused.

At the onset of the psychoneurosis, while with the Army in England, he feared that working in the heat would make him insane. It was found later that his blood pressure was elevated, and he assumed that any alteration in the circulation must have a harmful effect on the brain cells. He feared that he might faint and that the momentary failure of the circulation would cause further injury.

(Under treatment, his conviction of insanity was reduced to the fear that insanity was probable in the future. Against this he demanded endless, minute assurance): After leaving the service he had worked exposed (adequately protected) to the fumes of oil, solvents and molten metals. Since they could be smelled, they must have been inhaled and minute traces carried to the brain. "Could that have caused injury to the brain cells? Damage to what per cent of brain cells will cause mental symptoms? 1? 20? I asked him, "You know very well that men have worked there for many years without mental changes. Why do you fear that it will affect your brain cells?" Answer: "Their work does not require any special mental ability, but my precision type of thinking might be harmed." (Thus, there is something of exquisite delicacy in his intellect that is more vulnerable than the coarser mentation of others.)

He stated frankly his determination to have every test and to exhaust every possibility in investigating everything that might have the slightest effect on his mentality. He demanded an electroencephalogram. It was reported to be "within the limits of normal." He was preoccupied with numerous minor compulsions designed to protect or to test his mental status. He had episodes of conscious or forced breathing which were to insure an optimum supply of oxygen to the brain. He constantly tests himself, notes whether he sees objects or hears

sounds as other people do and whether they have the same significance for him. He examines his perceptions against the criteria of "time, place and person" to see whether they conform on the sane side. He has an "introverted form of thinking," which he explains as "a directed form of thinking," in which he is forced to "talk out" an expected sequence of events and in which he is too conscious that he is thinking. (Apparently this is an attempt to objectify the thought to see whether it sounds psychotic.) This is distasteful to him because, being compulsive, it is not fully under his control, thus implying insanity. Likewise, he does not like to have dreams because they cannot be controlled and indicate loss of contact with reality.

(His rigidity and absolutism are everywhere evident.) He is determined to govern himself by a set of rules that will give perfect assurance of retaining his mental ability. For example, he will never touch liquor. This is not the ordinary abstention; he would refuse a teaspoonful of paregoric offered as medicine. He defines his anxiety as due to "the necessity of proving or disproving certain things with nothing sufficing short of positive proof by methods of objective accuracy." (It is remarkable how articulate he becomes when he slips into the language of mathematical science.) This one-wayedness of thinking is illustrated by my challenge to him, "You expect the balance of the mind to be maintained like that of a mathematical equation the truth of which is completely destroyed by the minutest alteration on either side," disregarding the biologic facts of adaptability to injurious influences, the reversibility of pathologic processes and natural factors of safety.

ANXIETY AND DEPRESSION

When the superiority-rigidity pattern is widely and deeply established, any assault on the self image is so painful that there is likely to be a precipitous retreat into complicated, defensive devices, of which obsessions and compulsions are the most characteristic. However, there are milder forms in which the reactions may be simpler. In these the breach in the security feeling is not so unendurable that it must be avoided at any cost. If the difficulty is faced and combated directly, the manifestations are those of anxiety and depression with the usual symptoms of psychic and somatic reference. Here, as always, anxiety is the signal of a present, enduring conflict—a struggle to maintain the ideal superiority against contrary implications, while depression indicates the realization of defeat.

The following 2 cases are offered as examples of an anxiety-depression reaction in which the cause was the collapse of preexisting superiority feelings. In both cases there was a surface appearance of a motivation of inferiority. This is not inexplicably paradoxic, since the trauma actually was the threat of relative inferiority. The distinction lies in the fact that the person with the superiority feeling, with his emotional bondage to an impossibly exalted self perception, is called on to accept a lower status, while the person with the inferiority complex seeks only to hold or to attain a worth that is not too far below that of the average person. This difference is intensely practical. The psychotherapeutist cannot reassure the "superior" person to the point of restor-

ing his former perfectionist level, and the patient usually finds it impossible to adjust downward. On the other hand, the "inferior" person is easily satisfied, and it is usually possible to find in him sufficient assets to build up a reasonable degree of self confidence and serenity.

Case 2.—M. S., a woman aged 40, unmarried, was first seen on June 26, 1946, with the complaint of being nervous and depressed. In March 1943 she had been tense and had had pains all over her body. She had been under medical care for two years and had improved for a time, but for the past nine months she had been much worse than ever. She has constant depression with frequent crying spells, which she has to suppress because she must not disturb her two sisters with whom she lives, and who are ill. She can find no joy in anything. She would like to die but has no suicidal plans. She sleeps poorly, even with sedatives, and wants to get up and walk about the streets. On a few occasions she has done so. She awakens early with marked depression, which lessens later in the day. There is considerable variation from day to day, but there is a constant feeling of tension, with pressure in the head, tightness in the back of the neck, occasional headaches, fluttering in the abdomen and variable appetite, usually poor. She has difficulty in concentrating and believes that she is irritable.

The patient finished the second year of high school and had done rather well. Since then she has been a stenographer. Although she has been told that she does good work, she has not had a raise in five years. She considers herself a plodder. She believes that she is not a rigid routinist or inordinately neat and precise. However, she adds, significantly, that she has "gotten over that." She has few friends "but keeps them" (implying a purposeful selectivity?). Although she is not unattractive, there have been no love affairs, and she seems to have held aloof from them. She seemed a neat, gentle, refined, mouselike person. She thinks that she has never been cheerful or carefree. In point of fact, her life has been far from happy; she was one of those "whom the Lord hath fenced in."

Her mother died at 74, crippled by years of arthritis. The patient is the eighth of nine children. She lives with two sisters, both of whom are invalids. Helen has had myasthenia gravis for fifteen years, and her life is sustained only by neostigmine. She is unable to go out but requires little care except in the morning, when she must be helped to dress.

Irene had a radical mastectomy nine years ago and has not been well or able to work since. Her trouble had been diagnosed as colitis and she has lately had incapacitating pain in the back. (While the present study was in progress, this was found by roentgenogram to be due to metastatic carcinoma of the vertebrae.) Two brothers had been alcoholic. One had reformed; the other had been ill in March 1943 and had stayed with them. This was the time that her nervous trouble had begun. In August 1945 he again became ill; and, after some effort to nurse him at home, he was sent to a hospital, where he died suddenly of pulmonary embolism. Shortly after this, the patient entered the present, severer, phase of her illness. There has always been a great deal of chronic illness in the family, and the patient has the feeling that none of them ever recovers.

If it were possible for the less abundant life and cumulative misfortunes to produce a neurosis, they would seem to be adequate causes in this case. But far more significant ones become apparent when one studies the guilt feelings that assailed this patient. Although she was the main economic stay of her sisters, and although her duties as their housekeeper, nurse and attendant in the hours

outside her employment involved the sacrifice of almost all social and diversional opportunities, she still reproached herself. "I feel so helpless about them; they have so much work to do, and they are not able." She even blamed herself that she was going to a psychiatrist without their knowledge; it was an act of ill faith, a deceit by which she had placed herself out of touch with them. However, guilt complexes regarding her brother were of more critical importance. (It may be stated here that there was at no time any evidence of erotic interest in him.) She should have cared for him at home instead of sending him to the hospital, where he died. In this, she was to a degree responsible for his death. Moreover, since her brother was alcoholic and nonreligious, she was culpable in not having reformed him. In not having a minister attend him in his last days (although his death was unexpected), she had failed in her duty to provide for his spiritual salvation. She even found cause to reproach herself in the very fact of her illness, "I always thought that I was a good Christian, but I cannot be because I would have found consolation from that."

Comment.—In this case, a real superiority feeling had compensated for the lack of all the ordinary pleasures of life. The patient had been sustained, and even exalted by a sense of unfailing adherence to an ideal of virtue and duty. The self sacrifice, the restrictions and the narrowing of all outgoing interests imposed on her by her devotion to her unfortunate family were thus relatively painless. Indeed, it would probably have been impossible for her to have done otherwise because she was rigidly bound by her perfectionist estimate of what she ought to expect of herself as a "good Christian." She could forgo worldly pleasures because of her belief (variously expressed on several occasions) that a good Christian could find consolation no matter what he was called on to bear. It was in this conviction of her rectitude, and in this naïve cosmology that only good could come of good, that she had found contentment and security. But her guardian angel complex, competent to maintain her feeling of superiority up to this point, cracked under the strain when she sought to extend it over her brother. Here she faced realities which she could not control—the alcoholic addict who would not reform; the illness that could not be treated at home, and the impossibility of providing spiritual help before death. For these no ordinary person would long blame himself, but it is characteristic of the uncompromising nature of rigidity that this patient could find no mitigating circumstances in these "failures" and interpreted them as personal derelictions of duty. The depression produced by this thought suffered a secondary augmentation. It was a challenge to her concept of herself as a good Christian. This, in a sort of vicious cycle, confirmed her feelings of guilt, and she began to suspect that she had not been wholly devoted even to her sisters. The accusation that she was deceiving them by secretly consulting a psychiatrist is a sample of the extremity of the reproaches that arise when the security pattern is broken.

Psychotherapy was aimed at establishing this patient's self esteem at a level that was compatible with reality. It was explained that she had shown a devotion to her duty far greater than might have been expected by any ordinary human standard, that circumstances arise with which the best of us cannot cope. If she had failed to be a good Christian, it was apparent only in a certain lack of humility that had led her to expect of herself the perfection that is granted only to the angels. With this type of reeducation as to values, there was a substantial decrease both in the anxiety and in the depression. It is significant that the discovery that her sister had inoperable cancer of the spine did not mar the improvement.

CASE 3.—A. C., a man aged 22, was first seen on Sept. 29, 1941 and, except for an interruption of one year, was studied until June 1943. His first complaint was nervousness, poor appetite and episodes of aversion to food, so sudden that he was often unable to swallow that which was already in his mouth. However, above all, there were constant anxiety and depression, with violent accessions lasting for an hour or two. He saw no point in living; the world had become colorless, without interest or challenge. He was physically and mentally tired, especially in the mornings. Although he stated that he had been cheerful until two years ago, it developed that his trouble had begun insidiously three years before that. Examination revealed nothing physical that could be considered causative.

He was considered "high-strung" as a child, slept poorly and had nightmares. At the age of 8 he had a head injury, "was unconscious for thirty-six hours" and was made to stay in bed for three months. There were no sequelae. "Stomach trouble" in childhood was diagnosed as due to a neurosis when a roentgenogram revealed a spastic colon. He suffered from keratoconus and was severely handicapped visually until two years before consulting me, when more satisfactory lenses were prescribed. He had asthma, and later eczema of the hands. While attending an asthma clinic, he saw a distressed, cyanotic patient and acquired the compulsion to say "God forbid." This passed away in a few months.

He had been bright in school, but there had been a wide divergence between his intellectual and his social progress. He believed it was because he had been inept in games and athletics and because he had been a poor child in a community of richer children. In contrast with the more privileged group, he described himself as "Alice looking through a keyhole." He believed that little girls disliked him because of his puniness, his shabby clothes and the dermatitis of his hands, which was considered contagious and repulsive. Lack of spending money kept him from many activities. What he received was earmarked; there was never a nickel to spend casually. He knew that his mother had no more to give him, and he forced himself to be content, feeling that this was a sensible attitude. After his head injury he was set back into a lower grade in school and lost contact with his former classmates. He found the new ones "moronic" and avoided them. Thereafter he had practically no friends. However, he learned to capitalize his scholastic ability. His reading extended to serious, nonfictional subjects. He was rather precocious. At the age of 10 his opinions in family problems were listened to. He was regarded as rather encyclopedic and won respect but not friendship. His few acquaintances were conversational partners to whom he could display himself, and he loved to talk beyond their scope and to

give instruction. It occurs to him now that his omniscience might have been burdensome to others. His intellectual pursuits, since they could be practiced alone, contributed to his isolation; in the face of this he made a virtue of individualism.

His family was a striking setting of rigid attitudes. One brother, 2 years older, had manual skill and initiative, and the patient was taught that the best he could do was to assist or imitate him. He believed, however, that he was just as capable as his brother, or would be when he reached a corresponding age. His mother had small regard for his ability. She never encouraged him to further effort after failure; if he could not do a thing, it did not admit of his learning to do it. In his childhood illnesses she found an excuse for being absurdly restrictive and protective. Lively, robustious play was forbidden; active, noisy boys were naughty boys. There was a general fear of taking even the slightest chance. Until he was 14 or 15, he was not permitted to cross streets of heavy traffic alone, and in the supervised play of the schoolyard it was feared that he might take off his coat!

The inner relations of the family were considered more important than the external ones; they cultivated self sufficiency and then wondered why they had so few friends. Their interests were baldly utilitarian, with disregard for the social and diversional. They saw no need for a small boy to have toys. The child shared the family notion that physical and mental excellence could not coexist. He came to believe that a desire for athletic prowess was childish and was confident that his intellectual pursuits marked him as more mature.

His sex history was purely ideational. He insisted that there was no lack of sexual impulse and that he had overcome early moralistic inhibitions. He felt that his occasional masturbation was not quite right but was not greatly disturbed by it. He ascribed his inexperience to lack of money and to deficiency in secondary sex characteristics. Regarding the latter, he had recently elaborated the opinion that his trouble was an inferiority complex based on the lack of a full, deep, masculine voice, his scanty beard and body hair, narrow chest, poor muscular development and deficient sex appeal.

It was quite apparent that during his earlier years he had maintained a considerable degree of contentment and cheerfulness. The host of material disadvantages could be borne easily as long as he could hold to the conviction that his superior intelligence, his sensible disinterest in unattainable pleasures and his maturity of outlook would, when he faced the world, inevitably bring him success and happiness. When he left high school there was no money for college, and he studied bookkeeping at night school. Long before he completed the course, he decided that he was competent and took a job "on his nerve." He was quickly fired. After that there were long periods of lack of work and many disappointments. He sensed increasingly that his intellectuality was not helping him and that he was unfavorably different from others—a difference that he had once regarded as a mark of superiority and which he now realized was a disadvantage. This corresponded to his period of greatest depression, during which he had first sought treatment. Later, he got another job as bookkeeper and did very well. However, his disillusionment with himself was now so complete that, in preparation for being drafted, he gave up his job to study radio theory. He welcomed induction as a means of "escaping the situation in which he had developed and creating a new personality." He felt that he must make a new beginning, with opportunities and experiences like those of his associates, so that he could enter into normal contacts on an equal basis. (This occurred

during the latter part of his treatment, at a time when he had gained considerable insight and had improved significantly.) The following analysis is largely the result of his unusually skilful introspection.

The causes of his psychoneurosis appear to have become active at the time he left school and faced the problem of translating the assets he had assigned to himself into a successful career. It was then that he lost his confidence and mental repose. "Now everything is topsy-turvy. My interests do not seem important any more. The others—the dumbbells—have interests that seem more valuable; they have arrived somewhere." As anxiety and depression deepened, his first reaction was to rationalize his failure in such a way as to leave his personality estimate intact. Thus he recalled his childhood handicaps as superficial inferiorities which had prevented the fruition of his fundamental abilities. This is illustrated by the distinction that he made between his deficiency in secondary sex characteristics and his primary sex sufficiency. He believed that he had a too vigorous imagination, which had caused him to consider every eventuality until thought had impeded action and doubt of ability had caused loss of ability. (This was his misinterpretation of his flight from chance—a universal feature of rigidity.) He remembered strong object fears of childhood as explanatory of his fear of attempting anything lest he do it wrongly. He also believed that he was handicapped by some unfortunate, inherent inability to make a favorable impression.

When this structure failed him, he became less self sparing. He realized that he was incapable of acting like the average person, that in cultivating intellectuality as the only desirable asset he had failed to develop that familiarity with worldly things and that nice adjustment to them and to other people that give poise and maturity. He had been contemptuous of these things, believing that as time passed his success would be established as the inevitable corollary of his special abilities and learning. When time passed and nothing happened, his chief prop collapsed and his psychoneurosis reached its greatest severity. His excuse that the fault lay in his early disabilities gave way painfully, under therapy, to the understanding that the real defect was the self sufficiency and self esteem which, by depreciating the traits which he lacked, had isolated him from normal, average activities and attitudes.

Partly because of his intelligence (which was very real) and partly because he had been chastened into pliability, it was possible to induce a constructive reaction. The feeling of superiority was sacrificed. Convinced of the need for a basic change, he abandoned his "ivory tower" and moved deliberately to attain the commonplace. He entered the Army to be like other young men. At the time he was called into active service he was hopeful and free of anxiety. A follow-up was not possible.

This patient revealed several trends typical of the superiority pattern. There was a nuclear conviction of superior mental ability which must in due time be automatically confirmed by outstanding success. Even as a child he had assumed that all his actions and beliefs were inherently correct. Juvenile logic built up a doctrine of determinism by which he assured himself that he could not fail, since everything had been perfectly planned for the best future advantage. The very fact that he could forgo childish pleasures he took for evidence of maturity. Later he elaborated the rationalization of handicaps, and he decided that in trying too hard to compensate he had become self conscious and created an unfavorable impression. Here he developed a minor compulsion. When he was to make an important personal contact, he was forced to forecast it in his imagination, directing the conversation in such a way that it must result favorably. He believed

that this was to assure himself that success was possible but readily accepted the possibility that it might be an attempt to influence the event through the potency of thought.

Always he had been sustained by the certainty that when the proper time came disadvantages would melt away, deterrents would be outgrown and all would be well. Superior ability, perfect planning and precocious maturity must place him competitively far ahead of the "morons" and "dumbbells." Finally he had to face reality, and when success did not come to confirm his superiority the whole structure collapsed. There was a frantic grasping at new formulas to insure success or to excuse failure. He told himself that it was because he had been too optimistic and that he might do better if he took a more pessimistic approach (i.e., the superstition of the potency of negative thought). He elaborated a group of curious ideas, which may be called the "Jonah complex," and which took on the aspect of a special cosmology. Thus, he believed that natural forces were fated to act adversely in his case. Things were all of a piece in the sense that those who were successful or unsuccessful were uniformly so. This was related to a doctrine of beginnings: If the first attempt failed, it became the pattern for all future attempts (note here the influence of the mother's attitude). He decided, therefore, that the faulty relations of his early life had hopelessly determined the future. This rigid conviction of the finality of failure added to its overvaluation. Thence arose the excessive caution and planning which preceded every venture and the retreat from any task that might turn out badly.

Comment.—This case, like the previous one, wore a deceptive mask of inferiority. In reality, however, the handicaps that the patient stressed were unimportant as compared with his satisfaction with his ability and maturity, which could not be sustained when put to the test. It was only when the security of this self concept was shattered that the memories of disadvantages were mobilized and used with some satisfaction as the external factors to be blamed for his defeat. He had marked off a little plot of intellectuality to be peculiarly his own, had planted it with fantasies of success and walled it about with illusions of self sufficiency. He found security in the belief that he had encompassed within it everything worth while and had come to depreciate everything outside. When the wall crumbled, he saw for the first time a world with which he was out of touch and unprepared to cope. It was only surprising that he retained enough resilience to attempt to adjust himself on a new basis.

COMPULSIONS AND OBSESSIONS

The manifestations noted are relatively minor. The prognosis is much poorer when the superiority-rigidity formulations are so general as to invade the entire personality and when the patient's whole affective life is so dependent on a fixed self image that he dare not accept a revelation that endangers it. Here rigidity of outlook prevents the creation of new attitudes and softer judgments. To accept the physician as a guide involves the subjugation of self and the sacrifice of infallibility. Hence a satisfactory rapport is seldom obtained. In brief, the superior attitude

can hardly be adjusted downward. To attempt it provokes incredulity and hostility; to succeed may precipitate a depression far worse than the original neurosis. Since the psychopathologic mechanisms in these cases are essentially protective, they should be disrupted, if at all, with extreme caution.

Vicarious Annihilation.—The superiority-rigidity organization may be so vital to security that there can be no compromise. The person with a superiority attitude, in his bondage to perfectionism, is totally unable to integrate adverse elements into his personality concept either by extenuation or by compensation. Unfavorable ideas, memories or wishes can to no degree be admitted to consciousness. Their potentiality for pain is, indeed, so great that ordinary repression is not enough; for complete security the offending complex must be destroyed. However, since it cannot be faced in its reality and dealt with once for all, the annihilation of the enemy must remain only temporarily effectual. It fails because it can be accomplished only vicariously; for the intolerable, the untouchable, idea there must be substituted a symbol that is not too unpleasant for consciousness to take hold of. (There are close analogies in the symbolizations of magic. The witch doctor, to destroy a dangerous or an inaccessible enemy, pierces with needles an image fashioned to represent him. Traces of such magic can often be identified in compulsive behavior.[5]) Such a mechanism serves typically to nullify a major threat to the security of one's self estimate, such as would arise from the conscious realization or memory of a guilty thought or deed. It becomes, in effect, a prevention or an expiation.

The clearest and commonest examples of vicarious annihilation are seen in those obsessions in which the idea of dirt or contamination is substituted for complexes having to do with ethical, and particularly sexual, transgressions, with some form of ritualistic cleansing superimposed as compulsions. Quite outside of psychiatric experience, the lore of such symbolic release from guilt is overwhelming. Pilate washed his hands, and so did Lady Macbeth (although with less emotional relief). The Pharisee, leaving a wicked city, shakes its dust from his garments. Baptism is practiced. One frees one's self from traces of a morally repulsive contact by spitting, or even vomiting. Even the shower at the end of the day's work serves symbolically to separate toil from relaxation as much as for cleanliness. Indeed, it is practically impossible to speak of delivery from unpleasantness or guilt except in the figurative language of cleansing or rejection. The misophobe, however, lives out such figures of speech and destroys his guilt by washing it away. Yet the cleansing can never be permanently satisfying as long as the symbol, and not the reality, is combated. Indeed,

5. Levin, M.: Archaic Regression Phenomena as a Defense Mechanism in Schizophrenia, Arch. Neurol. & Psychiat. **24**:950 (Nov.) 1930.

the demands of absolutism are thwarted by the fact that the contamination must still persist as a trace, however minute, in spite of infinite dilution. It is for this reason that the patient with compulsion finds only temporary relief while yielding to the compulsion, which never quite attains its goal.

The material of the obsession, instead of being a symbol metaphorically derived, may be an obscure association split off from the repressed memory and permitted to remain in consciousness because of its innocuousness. Here a minor fragment is substituted for the whole complex and bears a reaction that would be appropriate to the latter (were it known) and bizarrely inappropriate to itself. This is illustrated in the case reported by Ross [6] of the obsessive fear of the number 13. Similarly, there are object phobias in which a fetish tenuously related to the complex is avoided or combated in its stead.

Case 4.—M. L., a man aged 20, for five years had suffered a compulsion to repeat an action three times or, occasionally, a multiple of three times. More specifically, when the thought occurred, and it occurred frequently, of any harm befalling a member of his family, he was compelled to repeat three times whatever he was doing at the moment. At the same time he had to keep the opposite thought steadily in mind. (This is a perfect example of a motivation involving the potency of thought.) The nature of the act was indifferent—tying a necktie, closing a door, picking up a pencil. The compulsion had been increasing in severity. He had attempted to combat it, but always there had been a mounting tension and anxiety until he yielded. A secondary anxiety attended the thought that he did not have the will power to resist.

This patient revealed typical manifestations of a perfectionist superiority orientation with attendant rigidity of ideas. He was a model youth. Since graduating from high school, he had been employed continuously at clerical work at a chain store company. He was well regarded by his employers and was content with his progress. It was evident that he was steady, industrious, neat and respectable. He was also something of a prig.

The patient was the oldest of five children. His father was an incapable person, who never fully supported the family. The mother kept a small dry-goods store to help out. She was proud and doting and regarded her son as a paragon. His importance increased as he earned more and became the financial backbone of the family. His opinion was decisive in all family transactions, and he was pointed out as an example to the other children. These he regarded as frivolous and rather mediocre, and it was he who corrected, scolded and even disciplined them. Thus, before the age of 20 this boy had become the support, mentor and guardian of his family. Socially he was ill at ease, not greatly interested in friends, and felt himself to be something of an outsider. He could not bring himself to enter at a common level into the spirit of convivial occasions. He regretted not being a better mixer.

There had been no sexual experiences. He desired them but could not bring himself to the point. There had been one episode of rather tepid petting which he believed had offered opportunities, but he recoiled from following it up. He

6. Ross, T. A.: The Common Neuroses, New York, Longmans, Green & Company, 1923, pp. 235-237.

had a sense of lost dignity in sexual relations. Masturbation had been quickly abandoned by the exercise of will power and self denial. He avoided erotic pictures and was embarrassed by sexy talk. He could not bring himself to pronounce obscene words. He had consistently inhibited sexual fantasies. His whole attitude was comprehended in the formula, "M. is not the sort of boy who does such things."

Motivating all these virtues was a striking array of clearcut and uncompromising notions. His ethics was a mixture of boy scout maxims and Victorian attitudes. Courage, will power and self denial were well defined, almost ponderable, values which one might possess and be saved or lack and be damned. There were no doubts or equivocations.

His rather vague notions of cosmology were naïvely credulous. He believed that mental telepathy might be possible and accepted literally the doctrine of the power of mind over matter. There was a general tendency to think of authorized values as fixed ones, operating with predictable results. There could be none of that looseness of planning which comes of the acceptance of unforeseeable factors.

It was felt unwise to pursue the investigation too far or fully to confront the patient with its implications. There seemed to be enough to explain his case. A self concept of perfection had been built up, with an attendant rigidity of thought directed to the control of all factors. This was shown by his role as benevolent sovereign, support and guardian of his family and by his unyielding moralism. (This itself may be construed, in accordance with popular religious belief, as serving partially to protect those dear to him.) However, one thing escaped him; there could be no sure protection against illness or accidents or other works of chance. This was an intolerable thing to one who demanded absolute security, and he fell back on the potency of thought as embodied in the ritual of repetition to destroy every possibility of an unfavorable eventuality. Fantasy interwove calamity, not directly with the thought of calamity, but with the circumstances attending the thought. This influence had to be unraveled in reverse order. When a baneful thought appeared, anything that the patient might be doing at that moment became a symbol invested with the evil potency of that thought. This could be neutralized, or exorcised, only by repeating the action in circumstances that would give it a beneficent symbolic value. This is pure magic—white magic opposing black magic—and it is noteworthy that the magic number 3 entered into the ritual.

In the treatment an indirect approach with no considerable revelation of mechanisms was felt to be safest. The therapeutist assumed the role of a minor Mephistopheles in an effort to weaken the boy scout moralism of sharply defined values and to induce a more tolerant attitude. Reeducation was directed to a more scientific perception of causes and effects, with emphasis on the necessity of accepting always the unavoidable element of uncertainty. His desire to protect his family was laudable, but the absurdity of his method, like all attempts at absolute control, was obvious. Surprisingly, a good result was obtained and the compulsion disappeared. However, the patient showed an increasing distaste for the follow-up sessions, and, when challenged with this, he acknowledged that he did not like his personality to be influenced by another. This is the superiority feeling at its worst and illustrates the impossibility of attaining a satisfactory rapport. There seems little reason to believe that the favorable results in this case were permanent.

Comment.—The incompleteness of this study leaves room for speculation. There is a strong possibility that the foregoing explanation is oversimplified. From the history there are abundant reasons to suspect a much more concrete motivation—a guilt reproach. It is probable that the obsessive thought of some misfortune, always poorly defined, befalling some member of the family was the unrecognizably mutilated representation in consciousness of a very specific, baneful wish directed to a particular person. For this the patient's father would seem to have been the most likely candidate. The frivolous siblings of whom the patient frankly disapproved also have some claims to eligibility. Such hate reactions, especially transient ones, are commonplace, and it is probable that they are always associated with a trace, however faint, of a death wish. This is expressed in "The Merchant of Venice," Act 4, scene 1:

Bassanio: "Do all men kill the things they do not love?"

Shylock: "Hates any man the thing he would not kill?"

To the ordinary, well adjusted person such thoughts are at first shocking, but they are quickly and satisfactorily assimilated by the realization that they are only partial and transient impulses, inconsiderable fragments of one's true feelings, and more than counterbalanced by one's prevailing affection. His practical philosophy assigns guilt only to actions, and the evil of an unworthy desire is nullified if opposing impulses predominate to produce acceptable behavior. The strictures of the perfectionist are much more rigid. If one has evil thoughts, one must to some degree be evil. Here, where thought has a value almost equal to deeds, and where the requirements for worth of character are absolute, even a fleeting improper impulse is construed as evidence of a guilt-laden defect. This cannot be integrated in a perfectionist system by any conscious mechanism. To have entertained a death wish is a trauma to the self image so severe that, if disintegration is to be avoided, it must be relegated to the unconscious and handled vicariously.

If one can accept the probability that this patient had held such a wish, it clearly had for him a double significance: (1) as evidence of a serious character defect and (2) as unloosing a potent thought that might find its mark in real calamity. The obsessive idea of an indefinite mishap becomes the symbol by which the repressed idea presents itself. The compulsion uses the potency of benevolent thought to destroy that of the baneful thought. The inconvenience and discomfort occasioned by the compulsion, as well as the whole picture of exaggerated devotion, are obvious expiatory manifestations.

Compulsions.—Certain compulsions and obsessions seem to represent direct efforts to complete the control of all factors against the possibility of unfavorable reality even when complexes or events that point up such

possibilities are not present. Doubt obsessions are typical examples. Confronted with alternatives, the normal person is satisfied with choosing a good one, realizing that, as likely as not, chance will upset the balance of a too finely drawn selection. The doubt-obsessed perfectionist, refusing to accept chance in his planning, can accept only the best. In the delay of evaluating all factors for that impossible decision, he is likely to achieve an inertia like that of the logical jackass, which, when placed exactly equally distant from two exactly equal bales of hay, starved to death.

Memory compulsions appear to be motivated by the need to preserve a concept of the perfect integrity of the mind. Often they are compulsions to remember names—names which may be as remote from any interest of the patient as Alexander's horse or Hamlet's father. The inability to recall them is attended by tension and anxiety which are not to be resolved until the missing name is found. It is significant that memory is the only mental faculty that can easily be tested by one's self, and the memory compulsion may well be the way of perpetually proving one's complete mental competence. To a person with such a compulsion it is intolerable that any fragment of his mental material might not be at his command at any time. The possibility of a deeper motivation, speculative, it is true, and perhaps somewhat mystic presents itself. To remember is a symbol, not only of one's mental perfection, but of one's life itself. The perception of having lived is inseparable from the succession of one's remembered experiences. Indeed, it is identical with it, and every hiatus in that succession is a fragmentary death. An amnesia is equivalent to nonexistence for the duration of that amnesia. "Every parting is a little death," might well be paraphrased, "Every forgetting is a little death." In this respect, the related meanings of "annihilation" and "oblivion" become identical meanings. The person with a memory compulsion, therefore, may perhaps be conceived of as maintaining with typical absolutism the wall against the minutest implication of aging and death.

INVOLUTIONAL DEPRESSION

The close, probably unvarying, relation of rigidity to involutional depression is a commonplace of psychiatric knowledge.[7] Less is known of the mechanism of this relation. It seems, however, that this psychosis is likely to appear whenever an external situation threatens loss of security to a person who has always required an inordinate amount of security (as exemplified by the rigid-superior personality) and at an age when there is a decrease of all those factors which might make possible some adaptation and compensation.

7. Muncie, W.: The Rigid Personality as a Factor in Psychoses, Arch. Neurol. & Psychiat. **26**:359 (Aug.) 1931.

CASE 5.—F. E., a man aged 46, first seen Feb. 26, 1944, was married and had had no previous psychiatric history. He presented the anxiety, agitation, unvarying depression, inertia and loss of all interests characteristic of involutional depression. He dated his trouble from Nov. 1, 1943, but it was obvious that it had begun before that. His domestic and sexual adjustment appeared to have been good; he was a sober, dependable person, who had always supported his family decently. Apparently, he had little desire for venture or change, as evidenced by the fact that he had worked steadily at one job for seventeen years. The significant part of his history was concerned exclusively with his work. He had been a painter, employed as a maintenance man in a large bank building. Until the time of his illness he had enjoyed his work, was conscientious and meticulous and felt that he was "doing it perfectly." He was sensitive to criticism but was rarely subjected to it. He had two men working under him and was proud of the way in which he handled his responsibility.

In April 1943, owing to the wartime shortage of workmen, he was offered night work (outside his regular employment) at a tempting salary. He tried it for a few nights, going to his regular job during the day. He continued this all summer, working two or three nights each week. He knew that he was neglecting his job at the bank but thought that it would not be noticed, and there seemed to be little emotional distress at first. However, in June, a valuable rug in the president's office was marred by dampness. Although it was not directly his fault, he blamed himself because he was in charge of the workmen and felt that it would not have happened if he had retained his old time efficiency. In September he went to the seashore on his vacation but was restless and unhappy and blamed himself for having cheated his employers. He determined then to devote himself exclusively to his job. But all the other workmen were then secretly doing outside work, and they "needled" him to join them (probably a paranoid projection). The patient yielded. The second night he became nervous; his legs "gave out," and he went home determined that this was the end. However, he tried it again in October, but after the first night he reported one-half hour late for work and was reprimanded. Although nothing further came of it, he became frightened that he was about to lose his job. To assure himself that he was still in good standing, he now applied for a raise. This was refused on the grounds that a ruling of the War Labor Board prevented it. An official of the union informed him that this was a misrepresentation. When his request was again rejected, he became so agitated that he handed in his resignation. He quickly changed his mind and was permitted to withdraw it. He was now so nervous that he carried on only with great difficulty. One morning he was too depressed and frightened to go to work, and he quit. He insisted, however, that he had been discharged for inefficiency and felt that he was disgraced. He was in bed for two weeks, and then his daughter was instrumental in getting him an easier job in the building where she worked. The depression deepened. He worried endlessly about the future—that he was incapable, and that there were new conditions of work with which he would be unable to conform. He had been working irregularly, with complete lack of interest or drive, and was tired before he started. His agitation lessened only when he could tell about his worries. He had no interests, responded to no amusements and tended to avoid people. He had crying spells, bewailed his folly at the bank job, and thought constantly of how he could get back to it, although he was sure that they would never have him again. Regarding his present job he said, "The work isn't hard, but they are wasting a lot of time trying to break me in. I can never be any good at it. I've involved someone else again; before long my daughter will be so ashamed of me that she will have to

quit her job." This patient received nine electric shock treatments at the Philadelphia Psychiatric Hospital, with great improvement. There followed a period of mild anxiety symptoms, from which he recovered. He made a good emotional and industrial adjustment.

Comment.—There can be little doubt of the direct relation between this man's loss of security and his psychosis. That security was entirely dependent on the stability of his job, a thing that he had long taken for granted. When he yielded to the temptation to do outside work, he quickly recognized that he was impairing his ability, and there was anxiety lest it be noticed and his job jeopardized. This anxiety increased the longer the defection was persisted in. There was a parallel loss in the security of his self estimation. Over many years he had taken pride in doing a "perfect job." His new inefficiency was a serious blow, especially since it involved a feeling of guilt in that he was expending elsewhere the productivity for which his employers were paying him. The very furtiveness of his activities was traumatic. His self reproach first expressed itself in the affair of the damaged rug; later it became general, and finally, at the psychotic stage, it spread far beyond reality. Thus, he was cheating his new employers by permitting them to waste time in trying to teach him, since he was fundamentally incapable, and he was to be the cause of his daughter losing her job. At the same time his insecurity spread to fill the future with insuperable difficulties. The delusion that he had been discharged from the bank was apparently a self-inflicted punishment.

Spread of Depressive Ideas.—Often a seemingly trivial change suffices to upset dangerously a satisfying routinism:

A skilled workman, promoted to a new kind of work, became anxious and depressed when he found his performance faulty. Unaccustomed to any incapacity, he could consider this only as evidence of a personal defect. He lacked the elasticity of judgment to realize that such imperfections accompany all new and unfamiliar efforts. It was possible to rescue this patient from an impending collapse by insisting that he be demoted to his previous status.

In involutional states, however, it is remarkable how quickly and thoroughly the depressive idea overruns every aspect of the personality. Once self perception in a rigid-superior system has been effectively breached, the whole structure falls apart. Patients in whom evidences of previous superiority are easily to be traced plunge into the depths of self depreciation and self accusation; rigid ideas and ideals are abandoned; all sense of security vanishes, and, instead of self sufficiency, there is a feeling of complete helplessness in the face of impending disaster. In this development overlapping phases are vaguely discernible. Early, anxiety indicates the active struggle; agitation marks the realization of impending defeat; sometimes obsessions and compulsions appear as feeble defensive reactions, and, finally, depression evidences the com-

plete surrender. It appears that precipitating causes having the common feature of impairing the sense of security are constantly present in these cases. Such a relation to outside factors can hardly be found in any of the other major psychoses. It is not contended that the superiority-rigidity organization is essential to this but, rather, that, with its inordinate demands for security, it is the most favorable matrix in which involutional depression can develop.

The massive breakdown of the superiority-rigidity system and the absence of effective protective mechanisms require explanation. It is suggested that, in accordance with the all or nothing prerequisites of its structure, once a single manifestation of the superiority has been sufficiently impaired, a doubt is thrown on every other manifestation, until, by a sort of subtle chain reaction, they all explode.

SUMMARY

The superiority complex is described as a more or less completely developed trend toward a secure and gratifying, even exalted, self estimation. A certain uniformity of personality traits is detectable, and an attempt is made to delineate them as a type. Any disruption of the superiority feeling is exceedingly painful, and the possessor, therefore, is distinguished by his inability to adapt himself to discordant realities. As a protection against these realities, he is totally committed to a fixity of views that will afford absolute security. These rigid formulations pervade the entire mental life. In the effort to eliminate uncertainties, a cosmology of cause and effect relations approaching the metaphysical may be constructed, while efforts to control events may show magic components.

Psychoneurotic phenomena appear when the superiority system has been breached by the impact of circumstances. The simplest is the anxiety-depressive reaction, indicating the direct reaction to the imminence of psychic pain. More spectacular, however, are the obsessions and compulsions, in which protection is achieved by one's accepting the offending agent into consciousness only in the form of a symbol, thus permitting its vicarious destruction.

It is suggested that involutional depression arises from external trauma to some phase of the security organization, with complete failure of all protective mechanisms. An explanation is offered for the rapid spread of the depression to involve every aspect of the personality.

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LESIONS OF THE SPINAL CORD (TRANSVERSE MYELOPATHY) IN ACHONDROPLASIA

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ACHONDROPLASIA is generally regarded as a disfiguring, but otherwise innocuous, condition derived from a well defined anomaly of cartilaginous development. The only clinical complication of achondroplasia generally recognized is that occasionally seen in obstetric practice, in which the disproportion between a normal-sized fetus and a dwarfed pelvis may necessitate cesarean section.

In this paper we wish to call attention to the occurrence of lesions of the spinal cord in achondroplastic adults. We shall try to demonstrate the etiologic relation between the basic developmental disorder and the neurologic syndrome and shall point out means of preventing or curing this incapacitating condition.

It has been stressed in the past that achondroplasia affects chiefly the extremities and the skull, accounting for the characteristic shortness of the limbs and the peculiar shape of the skull. The achondroplastic spine has been commonly regarded as "practically normal" in size and shape except for an "exaggerated lumbar lordosis" (*ensellure lombaire*, Porak [1]), which either was ascribed to an abnormal tilting of the sacrum (Pierre Marie [2]) or was regarded as only apparent, and actually due to the excessive development of the buttocks (Rischbieth and Barrington [3]; Jaroschy [4]).

Morphologic changes in the spine in achondroplasia and their clinical significance have been described by Donath and Vogl.[5] They

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1. Porak, C.: De l'achondroplasie, Clermont, Daie frères, 1890.

2. Marie, P.: L'achondroplasie, Presse méd. **8**:17, 1900.

3. Rischbieth, H., and Barrington, A.: Treasury of Human Inheritance, London, Dulau & Co., 1912.

4. Jaroschy, W.: Zur Kenntnis des klinischen Bildes der Chondrodystrophie, Beitr. z. klin. Chir. **83**:379, 1913.

5. (*a*) Donath, J., and Vogl, A.: Untersuchungen über den chondrodystrophischen Zwergwuchs, Wien. Arch. f. inn. Med. **10**:1, 1925; (*b*) Untersuchungen über den chondrodystrophischen Zwergwuchs: II. Mitteilung, Ztschr.

pointed out that abnormalities of the spine were a regular occurrence and that they produced changes in the shape of the individual vertebrae, as well as of the vertebral column as a whole, and that these changes were a result of the basic cartilaginous disorder. The decrease in height of the individual vertebral bodies accounts for the relative shortness of the whole spine. Of more practical importance, however, is the shortness of the pedicles, which is due to a premature synostosis of the centers of ossification of the body with those of the lamina. This leads to a considerable narrowing of the entire spinal canal, in either the anteroposterior or the frontal diameter, or in all diameters (general stenosis) (fig. 1). The spinal cord, on the other hand, is unaffected by the achondroplastic process and is of normal size. The space which the cord takes up within the spinal canal is therefore

Fig. 1.—Transverse section of a vertebra of an achondroplastic newborn infant (continuous line) and of a normal newborn infant (interrupted line). The vertebral foramen of the achondroplastic vertebra is considerably constricted in the anteroposterior diameter. (After Sumita.[5f])

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f. d. ges. Neurol. u. Psychiat. **111**:333, 1927. Various anatomic changes have been described before: (*c*) Kaufmann, E.: Untersuchungen über die sogenannte foetale Rachitis: Chondrodystrophia foetalis, Berlin, G. Reimer, 1892. (*d*) Simmonds, M.: Untersuchungen von Missbildungen mit Hilfe des Röntgenverfahrens, Fortschr. a. d. Geb. d. Röntgenstrahlen **4**:197, 1909-1910. (*e*) Dieterle, T.: Die Athyreosis, unter besonderer Berücksichtigung der dabei auftretenden Skelettveränderungen, sowie der differential-diagnostisch vornehmlich in Betracht kommenden Störungen des Knochenwachstums: Untersuchungen über Thyreoplasie, Chondrodystrophia foetalis und Osteogenesis imperfecta, Virchows Arch. f. path. Anat. **184**:56, 1906. (*f*) Sumita, M.: Beiträge zur Lehre von der Chondrodystrophia foetalis (Kaufmann) und Osteogenesis imperfecta (Vrolik), mit besonderer Berücksichtigung der anatomischen und klinischen Differentialdiagnose, Deutche Ztschr. f. Chir. **17**:1, 1910. (*g*) Breus, C., and Kolisko, A.: Die pathologischen Beckenformen, Leipzig, F. Deuticke, 1910, vol. 1, pp. 267 and 313. (*h*) Marum, G.: Ueber eine erwachsene chondrodystrophische Zwergin, Frankfurt. Ztschr. f. Path. **24**:663, 1920. Siegert.[21]

disproportionately large, at the expense of the subarachnoid and the epidural space. This leads to a corresponding narrowing of these spaces and to tight encasement of the spinal cord by the spine. Com-

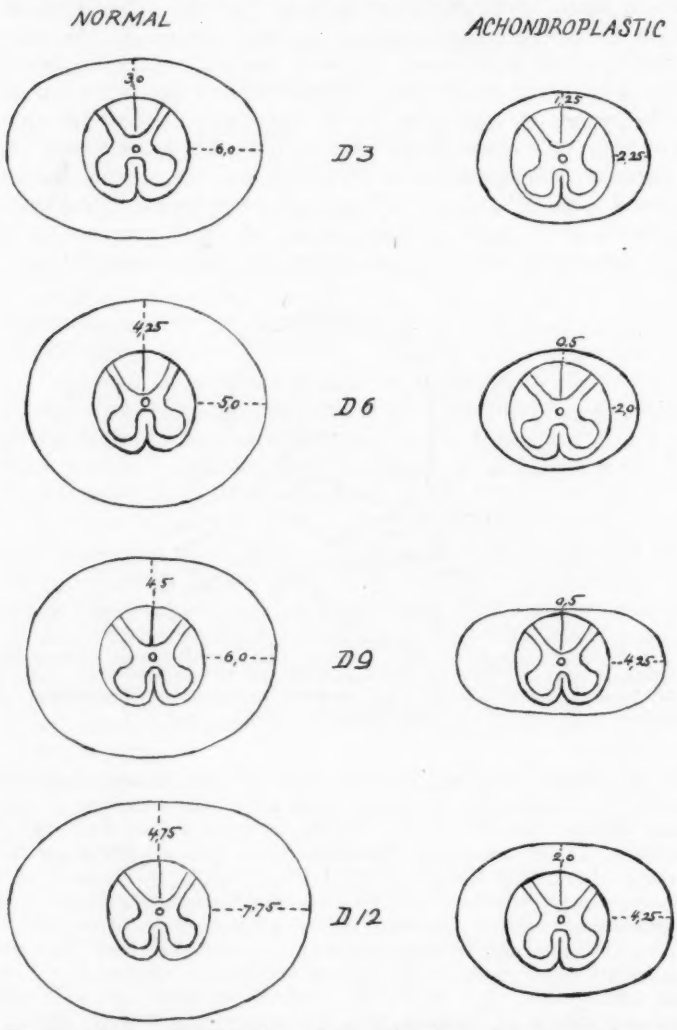

Fig. 2.—Schematic presentation of the diameters of the normal and the achondroplastic spinal canal in their relation to the diameter of the cord at the third, sixth, ninth and twelfth thoracic segments (after Donath and Vogl,[5b] p. 337).

parison of the relation of the spinal cord to the spinal canal in achondroplastic persons with that in normal persons (fig. 2) shows that the

distance from the bony wall of the spinal canal to the surface of the cord (taken up by the meninges, spinal fluid and vessels) is in places reduced to 0.5 or 1.0 mm., as compared with 4.5 or 6.5 mm. for the corresponding normal vertebrae. The implications of this condition become self evident, since the spinal canal normally is suspended in a good-sized cushion of water.

Donath and Vogl [5a, b] also drew attention to the shape of the dorsolumbar segment of the spine. A deformity of this portion had been occasionally described in achondroplastic persons but was regarded as unrelated to the achondroplastic process. Photographs or lateral roentgenograms in cases previously reported do not show the normal lordotic curve of the dorsolumbar portion of the spine. This segment may, in fact, be straight (type 1, "flat back"), slightly to extremely kyphotic (type 2 and 3) or sharply angular (type 4). In the last group of cases the gibbus formation is due to the presence of one or

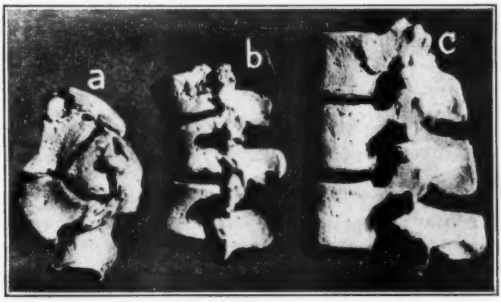

Fig. 3.—Lateral view of the twelfth thoracic and first and second lumbar vertebrae of (*a*) an achondroplastic skeleton with angular gibbus, (*b*) an achondroplastic skeleton with moderate kyphosis and (*c*) a normal skeleton.

two wedge-shaped vertebral bodies between the twelfth thoracic and the second lumbar vertebra.[6] A schematic drawing of the various types of achondroplastic spines is presented in figure 4. Profiles of achondroplastic dwarfs, displaying all degrees of deformity, from "flat back" to extreme angular kyphosis, are shown in fig. 5 (adapted from Donath and Vogl [5a, b]).

These authors stated the belief that the dorsolumbar kyphosis results from the fundamental achondroplastic disorder. In the course of normal development the spine, which is C shaped during early fetal life, gradually straightens itself. The force necessary to accomplish this is apparently supplied by the growth of the

6. Types 2 and 3 show a minor degree of wedging of the same vertebrae; even in type 1 a slight convergence of the upper and lower surfaces of the vertebral bodies is seen roentgenologically, but the expected curvature appears to be obliterated by muscular action and compensated by the intervertebral disks.

cartilage cells, which sprout in regular columns in the direction of the axis of the spine, thus converting the original low, prism-shaped anlage of the vertebral bodies into the high cubes of the fully developed ones. In the achondroplastic fetus, however, this process is interfered with by the absence of a well organized and directed growth of cartilage. The force necessary for unrolling the spine is insufficient; straightening is therefore incomplete. The segments which achieve the most satisfactory degree of straightening are the upper dorsal and the lumbosacral, as they are supported by the thoracic cage and the pelvic belt. The dorsolumbar junction, however, having no such rigid support, lags behind, and the achondroplastic infant is born with a more or less pronounced dorsolumbar kyphosis. The degree of kyphosis depends on the severity of the achondroplastic process.

The subsequent fate of the spine depends on the degree of kyphosis at the time of birth. The kyphosis remains permanent in many cases (types 2 and 3). It is compensated by adaptation of the intervertebral disks in other, milder, cases (type 1), in which slight wedging of one or more vertebral bodies is present, but is visible only roentgenologically. In some cases of severe type (type 4) the kyphotic portion of the spine collapses after the child has attained the erect position.[7] Complete wedging of one or two vertebral bodies (as seen in compression fractures) and subsequent backward subluxation of the "keystone" of the arch produce an angular gibbus.

Comparative Diameters of the Spinal Canal and Spinal Cord

	Diameter of the Spinal Canal, Mm.				Diameter of the Spinal Cord, Mm.		Diameter of Spinal Canal Chiefly Shortened
	Normal		Achondroplastic				
Vertebra	Frontal	Sagittal	Frontal	Sagittal	Frontal	Sagittal	
Th 3.....	21.0	15.0	13.5	11.5	9.0	9.0	Frontal
Th 6.....	19.0	17.5	13.0	10.0	9.0	9.0	Sagittal
Th 9.....	20.0	17.0	16.5	9.0	8.0	8.0	Sagittal
Th 12.....	24.5	18.5	17.5	13.0	9.0	9.0	Frontal

Donath and Vogl published 3 cases in which a wedge-shaped, posteriorly displaced first lumbar vertebra permitted the anterior portions of the twelfth thoracic and second lumbar vertebrae to articulate with each other. They cited 4 similar cases from the literature. Since their publication, 4 additional cases have been reported (Wahren,[8] 1931; Dale,[9] 1931; Gottesbüren,[10] 1932; Freund,[11] 1933), all of adults.

7. In confirmation of this hypothesis may be cited a recently published case of achondroplasia (Gottesbüren[10]). The patient was first seen at the age of 1½ years with pronounced dorsolumbar kyphosis. Orthopedic treatment, instituted at once, succeeded in correcting the deformity and preventing its developing into a gibbus.

8. Wahren, H.: Achondroplasia atypica, Acta orthop. Scandinav. **2**:87, 1931.

9. Dale, T.: Unusual Form of Familial Osteo-Chondrodystrophy, Acta radiol. **12**:337, 1931.

10. Gottesbüren, H.: Beitrag zur Chondrodystrophia foetalis, Arch. f. Orthop. **31**:321, 1932.

11. Freund, E.: Spastic Paraplegia in Achondroplasia, Arch. Surg. **27**:859 (Nov.) 1933.

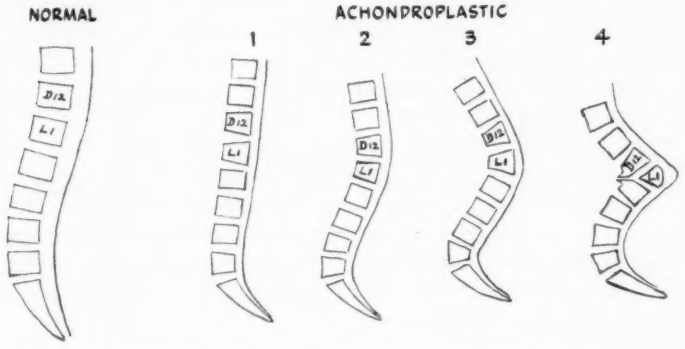

Fig. 4.—Normal and achondroplastic spines (four types).

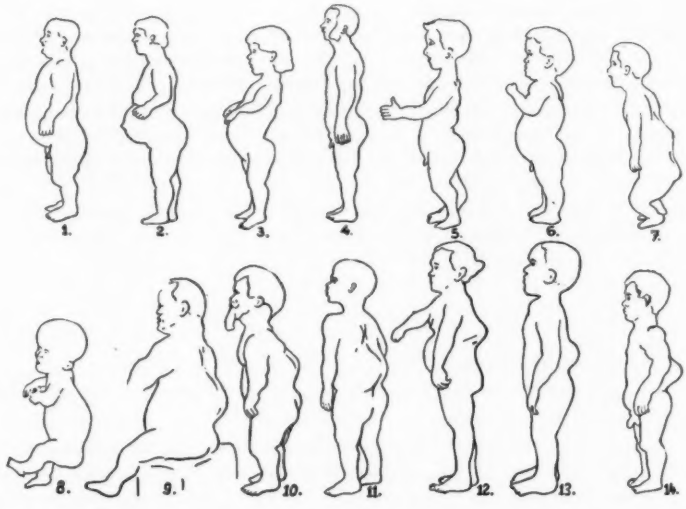

Fig. 5.—Profile views of achondroplastic dwarfs, representing various types of spinal deformities: *1* (Falta [12]) and *2* (Rischbieth and Barrington [3]), type 1, straight back; *3* (Turner, W.: Achondroplasia, Practitioner **10**:263, 1899) and *4* (Edgeworth, F. H.: Discussion on Achondroplasia, Bristol-Med. Chir. J. **17**:27, 1899), type 2; *5-8*, type 3, arcuate kyphosis of various degrees (*5* [Balme, H., and Reid, A. D.: Notes on Achondroplasia, Practitioner **73**:780, 1904], *6* [Duken, J.: Ueber Chondrodystrophie, Ztschr. f. Kinderh. **26**:65, 1920], *7* [Parhon and Shunda [15a]], *8* [Jansen, M.: Achondroplasia: Its Nature and Its Course, Leyden, E. J. Brill, 1912]; *9-14*, type 4, angular gibbus (*9* [Donath and Vogl [5a]], *10* [Parhon, Shunda and Zalplachta [15b]], *11* (Muraz, G.: Le bouffon d'un roi négre, Presse méd. **31**:1781, 1923], *12* [Frangenheim, P.: Chondrodystrophische Zwerge, Fortschr. a. d. Geb. d. Röntgenstrahlen **17**:69, 1911], *13* [Pires de Lima and Garrett: Nanisme achondroplasique, Presse méd. **32**:1284, 1924]; 14 [Donath and Vogl [5a]]).

These observations show that some degree of arcuate dorsolumbar kyphosis is inherent in the achondroplastic process; the formation of an angular gibbus, however, is a complication during postnatal life and due to secondary postural influences. Gibbus has never been observed in a newborn infant.

These anatomic anomalies became of practical importance when it was shown that progressive paraplegia developed in some achondroplastic adults and that a correct understanding of the relation of the lesion of the cord to the underlying skeletal changes opened up a promising approach to treatment. To date, 9 cases of transverse myelopathy associated with achondroplasia have been published, to which we add a new observation.

REVIEW OF CASES

CASE 1.—Falta [12] recorded the case of an achondroplastic dwarf aged 17 years who had had paresthesias and weakness of both legs for six months. Examination revealed spastic paraparesis (weakness, spasticity, patellar and ankle clonus and the Babinski sign) and hypesthesia and hypalgesia below the level of the costal margin, the disturbances being less pronounced below the iliac crest and least in the feet. The spine showed "lumbar lordosis and dorsal kyphosis."

CASE 2.—Keményffi [13] described the achondroplastic father of 8 achondroplastic children in whom, during the last years of his life, signs referable to the pyramidal tract developed. The spine was said to have shown "the characteristic lumbar lordosis with dorsal kyphosis."

CASE 3.—Maas [14] reported the case of an achondroplastic woman who on first examination had complained of urinary incontinence. The abdominal reflexes were absent. Five years later she showed signs of mild paraparesis, with patchy anesthesia of both legs. Autopsy observations are recorded later in the paper.

CASES 4 and 5.—Parhon and Shunda [15] published the histories of 2 cases. The first, that of a man aged 31, had increased deep reflexes on the left and a Babinski sign on the right side; no sensory disturbance was noted.

The second was that of a man aged 57, said to have "absence of the abdominal reflexes, increased deep reflexes and a Babinski sign on the right side."

CASE 6.—Zosin [16] reported the case of an achondroplastic man aged 20 who was admitted for cold abscess of the sternum. Neurologic findings included "exaggerated knee jerk and ankle clonus." No motor disturbance was recorded.

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12. Falta, W.: Die Erkrankungen der Blutdrüsen, Vienna, Julius Springer, 1913, p. 405.

13. Keményffi, A.: Familial Chondrodystrophy, Gyógyászat **64**:631, 1924.

14. Maas, O.: Beitrag zur Kenntnis des Zwergwuchses, Ztschr. f. d. ges. Neurol. u. Psychiat. **57**:196, 1920.

15. (*a*) Parhon, C., and Shunda, A.: Nouelle contribution à l'étude d'achondroplasie, Nouv. iconog. de la Salpêtrière **26**:185, 1913. (*b*) Parhon, C.; Shunda, A., and Zalplachta, J.: Sur deux cas d'achondroplasie, ibid. **18**:539, 1905.

16. Zosin, P.: Un cas d'achondroplasie, Nouv. iconog. de la Salpêtrière **23**: 31, 1910.

CASE 7.—Albrecht and Ranzi's[17] case was that of a man aged 46 with achondroplasia. Paraplegia developed over the course of ten years. He first complained of cramplike pain in the calf muscles when walking or standing. Difficulty in walking increased until, one year before admission, the patient had become completely bedridden. He then had urinary frequency and occasional incontinence of the bladder and bowels. Both legs were completely paralyzed, with the usual signs of damage to the pyramidal tracts. From the groin and the iliac crests downward there was increasing sensory loss for all modalities. Roentgenograms of the spine showed slight wedging of the twelfth thoracic vertebral body, with mild kyphosis of the lower thoracic portion of the spine. There were prominent marginal osteophytes at the lower thoracic and upper lumbar vertebral bodies. No spinal fluid could be obtained on repeated lumbar puncture. A diagnosis of compression myelitis at the level of the twelfth thoracic to the first lumbar vertebra was made.

CASE 8.—Donath and Vogl[5a] reported the case of an achondroplastic man aged 57 who had been born with an enormous "outgrowth" of the lower portion of the back. For five years before hospitalization he had suffered persistent pain in the left leg, and in the last six months he had experienced increasing stiffness and immobility of the left leg, pain in the right leg, urinary frequency and, finally, incontinence. He was a typical achondroplastic dwarf, with a rigid angular gibbus at the first lumbar vertebra (fig. 5, *9*). He had Argyll Robertson pupils and the signs of aortic regurgitation. There was retention overflow of the bladder. The lower extremities showed almost complete paraplegia. There was increasing hypesthesia of the left leg from the distribution of the third lumbar segment downward and of the right leg from the fourth lumbar segment downward. The knee and ankle jerks were clonic, and Babinski and Oppenheim signs were elicited on each side. The abdominal reflexes were present. Roentgenologic examination revealed that the first lumbar vertebra was quite small and was wedge shaped and somewhat displaced backward. The twelfth thoracic and second lumbar vertebrae showed less wedging, and they articulated with each other in the anterior half of their bodies (fig. 3 *a*). The Wassermann reaction of the blood was 4 plus. Antisyphilitic treatment was given for a year without effect. Laminectomy was proposed to the patient, but permission was refused. Two years later the neurologic findings were essentially unchanged. Lumbar puncture between the fourth and fifth thoracic vertebrae yielded a few drops of spinal fluid. At this level the manometric status was normal, and chemical, cytologic and serologic examinations gave normal results. The diagnosis was transverse myelitis at the level of the second lumbar segment. The patient died four years after his first admission, of a furuncle of the lip with septicemia.

CASE 9.—Freund[11] reported the case of a woman aged 21 with typical achondroplasia; pronounced kyphosis of the lower part of the back had been present since childhood. She was admitted for progressive paralysis of the legs, which were spastic and showed ankle clonus, considerable diminution of active motion and disturbance of sensation for all modalities, particularly on the left side. The sensory changes indicated a lesion at the third lumbar segment of the spinal cord. Roentgenologic examination of the spine showed a gibbus of about 90 degrees in the dorsolumbar region, the apex of which was formed by the second lumbar

17. Albrecht, O., and Ranzi, E.: Compressionsmyelitis bei Chondrodystrophie, Wien. klin. Wchnschr. **39**:1241, 1926.

vertebra. This vertebra was wedge shaped, smaller than the adjacent ones and slightly displaced posteriorly, so that the first and third lumbar vertebrae were in apposition in their anterior portions. These vertebrae showed considerable marginal exostoses.

These case abstracts prove that slowly developing lesion of the dorsolumbar portion of the cord occur in achondroplastic dwarfs. The incidence may be higher than is indicated by a review of the literature, for a relation between these two conditions has not been suspected and attention has probably been devoted to the growth anomaly rather than to the seemingly unassociated neurologic disorder. The available material appears sufficient to suggest strongly that the changes in the vertebral column are directly responsible for the reported lesions of the cord.

Donath and Vogl attempted to clarify the relation of the skeletal changes to lesions of the cord by analyzing the operative findings in Albrecht and Ranzi's [17] case (case 7) and by postmortem studies of their own case (case 8). The only other published autopsy on a case of this kind (Maas) does not contain a detailed report on the spine or the spinal cord.

Case 7 (Albrecht and Ranzi [17]).—Operation was performed for relief of complete spastic paraplegia. The dura was nonpulsating and bulged from the operative gap. The spinal canal appeared too tight for the dural sac. At the level of the tenth thoracic vertebral body a constriction of the whole circumference of the dural sac was seen. Below this zone the dura was observed to be adherent to the leptomeninges; above it a large amount of spinal fluid escaped after incision of the arachnoidal sac. The constricted portion of the cord appeared soft. Considerable improvement took place after the operation; sensation returned; bladder function became normal, and motor power of the legs increased to such a degree that the patient could finally move about on crutches.

Case 8 (Donath and Vogl).—The patient died after four years of observation. Postmortem examination (by Dr. J. Erdheim) revealed essentially syphilitic aortitis, angular kyphosis of the dorsolumbar portion of the spine and extreme constriction of the entire spinal canal. The spinal cord filled the canal completely. All the joint surfaces of the intervertebral articular processes were rough and irregular. The spinous processes of the twelfth thoracic to the second lumbar vertebra were curved downward and fused with each other. The pedicles appeared considerably shortened and were occasionally virtually absent. As a result, the laminas were drawn close to the vertebral bodies, making the vertebral canal much smaller than normal, and triangular instead of elliptic. At the eleventh thoracic vertebra the canal was particularly deformed and further constricted by the prominence of the articular surfaces of the articular processes as they extended into the lumen of the spinal canal (fig. 6). These joints showed signs of severe osteoarthritis, they were very broad and mushroom-like, were surrounded by small osteophytes and approached each other at the expense of the spinal canal. At the level of this stenosis, for about 1 cm. of its length, the spinal cord was greatly narrowed in its diameter and conspicuously softened.

Neuropathologic examination (Marburg and Pollak) revealed a lesion of the spinal cord localized in the upper lumbar portion. The first and second lumbar segments (corresponding to the eleventh thoracic vertebra) were considerably reduced in their total cross section; the second showed also indentation posteriorly in the midline (fig. 7). There was patchy (nonradicular) degeneration of the posterior columns and, to a slight degree, of the lateral columns. Starting from these segments, ascending degeneration in the posterior columns (fig. 8) and descending degeneration of the pyramidal tracts (fig. 9) were observed. These findings were interpreted as an incomplete transverse lesion of the "vascular myelitis" type, due to a local disturbance of blood supply. The indentation, already mentioned, corresponds to the inflow area of the posterior septal artery, and it was thought probable that the lesion could be accounted for by degeneration of an area supplied by this vessel.

These 2 cases showed that there was inordinate tightness of the spinal canal throughout and that this constriction was extreme in

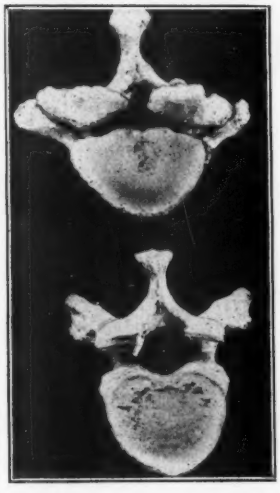

Fig. 6.—Cranial aspect of the eleventh thoracic vertebra in case 8, showing the narrowing of the spinal canal and the mushrooming of the superior articular processes, due to osteoarthritis. This deformity causes further encroachment on the spinal canal. A normal eleventh thoracic vertebra is shown below.

the lower thoracic portion of the spine, where osteoarthritic osteophytes had developed, encroached on its lumen and could lead to interference with the local blood supply, resulting in localized transverse myelopathy. Laminectomy and decompression of the affected segment were carried out in case 7 and were followed with notable regression of paralysis.

The operative observations in Freund's case represented a virtual replica of the autopsy observations in Donath and Vogl's case.

Case 9 (E. Freund).—After three months of treatment with traction, during which no definite improvement was seen, laminectomy was performed from the twelfth thoracic to the second lumbar vertebra (i. e., of the vertebrae forming the vertex and the adjacent portions of the gibbus). The cord was found to be angulated and nonpulsatile. The dura formed a thin transparent membrane, which was tight over the cord; it was not opened. A probe passed above and below this point met with no obstruction. After the operation, flaccid paraplegia developed, and a second operation was performed for possible hematoma; but nothing was found to account for the deterioration in the patient's condition. It was assumed that some injury to the cord had taken place during the operation. Improvement was slow. Six months later the patient could walk a few steps on crutches, but he never regained his preoperative status.

Freund's case (case 9) differs from Donath and Vogl's (case 8) in only one point: The vertex of the dorsolumbar gibbus was one

Fig. 7 (case 8).—Transition from the first to the second lumbar segment, showing marked decrease in the total cross section. There are patchy degeneration in both posterior columns, slight myelin degeneration in both lateral columns and deep indentation of the posterior columns from the periphery. This segment of the cord corresponds to the eleventh thoracic vertebra (fig. 6).

segment lower (at the second lumbar). The two cases were exactly similar in respect to the congenital nature of the deformity, the development of the paraplegia and the gross anatomic observations (at autopsy and at operation, respectively). The identical character of the pathologic changes in the cord may therefore be postulated by analogy. The site of the lesion should not have been expected at the level of the rigid gibbus but cranial to it (tenth to twelfth thoracic), where abnormal motion of the spine was liable to cause reactive osteoarthritis. This, incidentally, would have been in agreement with the sensory level, which localized the lesion in the third lumbar segment of the

cord, corresponding to the level of the eleventh thoracic vertebral body. The failure of laminectomy in this case may be accounted for by its limitation to the level of the gibbus, which was not the level of the

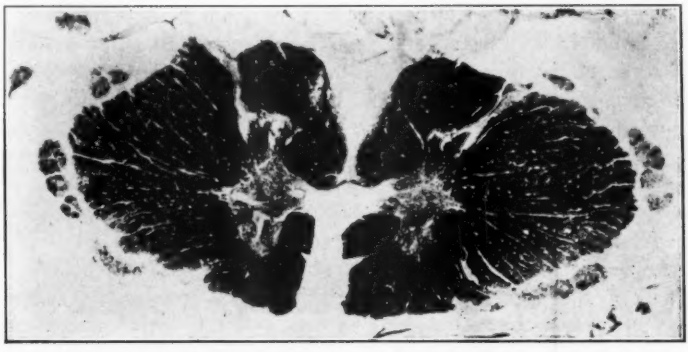

Fig. 8 (case 8).—Twelfth thoracic segment, showing symmetric bilateral degeneration of the most medial parts of the fasciculus gracilis and a small focus in the right fasciculus cuneatus.

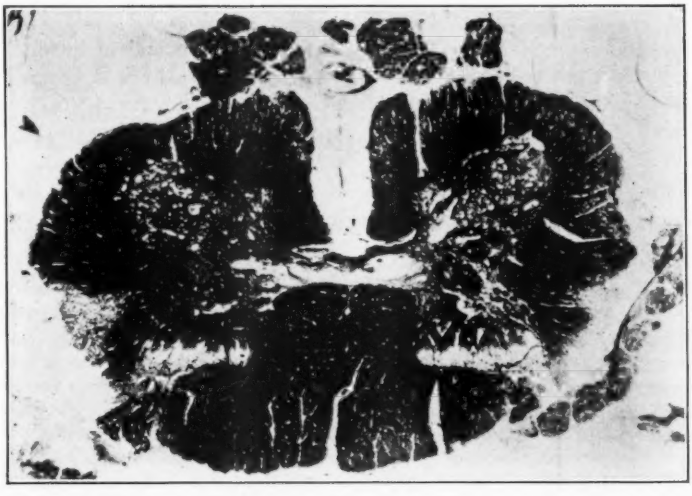

Fig. 9 (case 8).—Third lumbar segment, showing large asymmetric foci of degeneration in the lateral columns.

lesion of the spinal cord. In this way, the actual site of the compression was apparently missed. Postoperative edema within the tight encasement of the spinal canal may have choked the cord in the affected

area and accounted for the unfortunate postoperative course (Kennedy, Denker and Osborne [18]).

Conclusion.—Slowly developing transverse lesions of the cord, of varying degree, are occasionally encountered in adult achondroplastic dwarfs. The combination of these conditions is not a coincidence but is related to one of the fundamental skeletal changes in achondroplasia, the constriction of the spinal canal. In the majority of cases of achondroplasia the narrowness of the spinal canal is of no consequence, as it just accommodates the spinal cord and its membranes. This holds true even if the spine is greatly deformed. Kyphosis of the dorsolumbar region is common, and angular gibbus is not exceptional in persons with achondroplasia. In some cases hypertrophic osteoarthritis develops just above the dorsolumbar kyphosis, i. e., at the tenth to the twelfth thoracic vertebra, perhaps as a reaction to abnormal motion in this region of the spine. Osteophytes developing around the intervertebral articular processes at this level encroach on the spinal canal. Cord, nerve roots and their vessels are thereby exposed to progressive compression because of the virtual absence of a subarachnoid space and of cerebrospinal fluid. Compression of the nutrient vessels of the cord leads to degenerative changes at the affected level and causes slowly developing lesions of the cord. As direct pressure on the cord is probably confined to the area of the osteophytes projecting from the articular processes, complete subarachnoid block is not to be expected. Laminectomy carried out in time will decompress the tightly encased spinal cord, allow the reestablishment of local blood supply and thus initiate recovery from the neurologic lesion.

REPORT OF A NEW CASE

We are in a position to add an interesting observation to this disease picture.

A. C., a Negro aged 30, was admitted to the neurologic and neurosurgical service of Bellevue Hospital (Cornell) on April 2, 1941. His chief complaints were weakness of the legs and unsteadiness. He had been in good health until one year before admission, and had worked as a janitor. His illness began with indefinite malaise, which progressed to noticeable general weakness, most marked in the lower extremities, and accompanied with unsteadiness in gait, particularly when he arose from bed in the morning. This at times had been so severe that he had almost fallen. Gradually, a vague feeling of distress developed in the lower part of his back and increased to a dull ache in the lumbar area, as though his "back was broken." A gnawing ache would at times radiate down the back of his thighs and legs, giving him "misery." Coincidentally, micturition had become more frequent and abrupt. He had noticeable urgency and was occasionally unable to hold his urine. He also experienced increasing inability to consummate coitus;

18. Kennedy, F.; Denker, P. G., and Osborne, R.: Early Laminectomy for Spinal Cord Injury, Am. J. Surg. **60**:13, 1943.

the psychic urge was present, libido undiminished and erection adequate; but completion was not possible, and detumescence occurred by lysis, without ejaculation or orgasm. The rest of his history was noncontributory.

Physical examination revealed a well developed, well nourished Negro dwarf, in no acute distress. He had a large skull and depressed nasal roof. His upper extremities were relatively long, reaching to the middle of the thighs, and were angulated laterally at the elbows; his fingers were normally developed. His lower extremities were short and deformed, with "boomerang tibias," bilateral hallux valgus and bunions. The lower part of his back was slightly kyphotic, with a very deep lumbosacral depression and prominent buttocks.

The general physical status was essentially normal.

Neurologic examination revealed nystagmus in all directions, more pronounced and coarser on gaze to the right, finer and more active on gaze to the left and slight on upward gaze. The cranial nerves were otherwise normal. No sensory changes were noted. Slight weakness of the extremities was present. Coordination was intact. The deep reflexes were hyperactive. The Rossolimo sign was present on the right side. No other pathologic reflexes were elicited. The abdominal reflexes were absent. Gait was unsteady, with a tendency to fall to the right and backward.

The urine was normal; the blood count and blood chemistry, and the nonprotein nitrogen and sugar contents were normal; the Wassermann reaction of the blood was negative.

Roentgenographic examination of the skeleton (figs. 10 and 11) revealed a moderately wedge-shaped deformity of the twelfth thoracic vertebra with slight loss of height anteriorly. This was interpreted as a compression fracture. There was considerable marginal osteophytic formation on the adjacent surfaces of the bodies of the eleventh and twelfth thoracic vertebra, which was more pronounced on the left than on the right. No sign of hypertrophic osteoarthritis was seen elsewhere. Slight kyphosis of the dorsolumbar portion and excessive lordosis of the lower lumbar part of the spine, with the sacrum tilted backward almost horizontally, were noted. The long bones were greatly deformed, especially the femurs and tibias.

No fluid was obtained on repeated lumbar punctures. With two needles in place, sterile saline solution injected through the lower needle oozed out from the upper (indicating block).

On a subsequent occasion, 2 cc. of clear spinal fluid was obtained. Pressure measurements could not be made. The fluid dripped at a rate of about 1 drop every thirty seconds. It was not xanthochromic; the Pandy reaction for globulin was 2 plus; the total protein measured 80 mg. per hundred cubic centimeters. Another spinal tap, done at the second lumbar interspace, revealed a pressure of 105 mm. (fluid flowed slowly), which rose and fell promptly with variations in abdominal pressure. Jugular venous compression was effective, but the rise was less than normal; the fluid was crystal clear. These findings were interpreted as indicative of partial subarachnoid block.

Myeloscopy (Dr. J. L. Pool) revealed "thickened dura, block and absence of the cerebrospinal fluid, no pulsation of the nerves (with the instrument in the center of the cauda equina), several adhesions and several pale edematous roots; the spinal canal was narrowed." Studies with iodized oil U. S. P., done later (fig. 10), indicated partial block between the eleventh and the twelfth thoracic vertebra.

During ten weeks of observation the patient made no progress. About a month after admission he began to complain of increasing pain and stiffness of his back,

severe pain and cramps in his legs and greater difficulty in walking and in controlling his bladder. He spent many nights sitting in a chair, unable to sleep, often crying.

No agreement concerning the nature of the neurologic lesion or the cause of the skeletal changes and their possible relation could be reached at that time. However, a lesion of the cord between the eleventh and twelfth thoracic vertebrae was evident, and, though its cause remained obscure, a compression of the cord was probably present and a laminectomy was agreed on.

At operation (June 19, 1941) the spinous processes of the third, fourth and fifth lumbar vertebrae were removed, as well as the laminas of the vertebrae. This procedure was extremely difficult, owing to the pronounced lordosis at this level of the spine and the small size of the spinal canal. The dura was normal

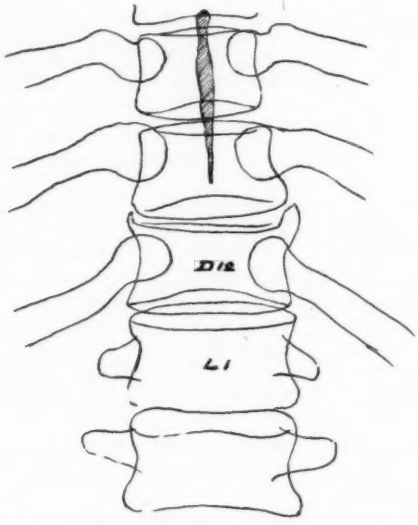

Fig. 10.—Sketch from anteroposterior roentgenogram of the dorsolumbar junction, showing marked osteoarthritic osteophyte formation, confined to the adjoining surfaces of the eleventh and twelfth thoracic vertebrae. The pictures also indicate iodized oil block at this level.

in appearance; it was opened and retracted. The spinal canal was found to be about one-half normal size, and the nerve roots were densely packed within it. There was no evidence of tumor or herniated nucleus pulposus. The postoperative diagnosis was congenital anomaly of the spinal cord.

After operation the patient had a moderate amount of pain in the operative area. On the twenty-seventh postoperative day, the patient was walking about, with only slight pain in the transverse arch of the right foot. This pain diminished when he began to wear shoes. He was discharged on the twenty-eighth postoperative day.

The patient was readmitted to Bellevue Hospital (Third Medical Division, New York University) five weeks later (August 22) with complaints of excru-

ciating pain in his back and legs, of one week's duration. He reported that he had had marked relief from pain immediately after laminectomy and had walked without support four weeks after the operation, whereas prior to it he had been able to move around only with the aid of canes. One week before admission he slipped while walking, "caught a stoop" to avoid falling and felt something slipping or giving way in the operative area. He was able to go home, but during the following night there developed a gnawing, ever increasing pain in the lower part of his back; this pain radiated around his flank to the right groin and down the back of both legs. It persisted and was present even at rest. He had

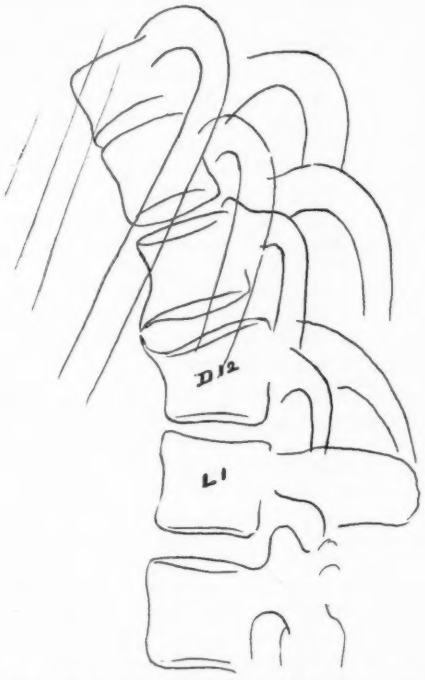

Fig. 11.—Sketch from lateral roentgenogram of the spine, showing wedge-shaped deformity of the twelfth thoracic vertebra and osteophyte formation between the twelfth and eleventh thoracic vertebrae.

been unable to straighten his back or to walk. The bladder trouble, urgency of micturition and relative incontinence also recurred and became worse.

On physical examination he was found obviously to be in great pain. Over the lumbar portion of the spine there was a well healed scar; this appeared slightly swollen and was exquisitely tender. There was a Patrick sign on the left; otherwise, the status, including the neurologic condition, was in no way different from that on his first admission.

Three to four injections of meperidine hydrochloride (demerol hydrochloride®), 100 mg., a day were required to keep the patient fairly comfortable.

On examination, on August 23, these questions arose: 1. What type of dwarfism did the patient represent? 2. Was there a relation between the skeletal anomaly and the assumed lesion of the cord? 3. What was the cause of the present painful episode?

1. It was felt that a diagnosis of achondroplasia was justified on account of the characteristic shape of the skull, the *micromélie rhizomélique* of the lower extremities and the mushrooming of the femoral head (roentgenogram), the acute lumbosacral angulation, the horizontal position of the sacrum, the wedge-shaped twelfth thoracic vertebra and, particularly, the narrowness of the spinal canal, an anomaly unknown in any other condition. The extreme curving of the tibias, resembling rickets, is commonly seen in patients with typical achondroplasia (incidentally, called "fetal rickets" by early workers). Absence of rachitic changes in the spine and ribs made the diagnosis of rickets unlikely. The absence of involvement of the upper extremities by the achondroplastic process did not rule out achondroplasia. Sparing of a part of the skeleton by the achondroplastic process, e. g., unilateral involvement ("hemiachondroplasia") or sparing of the lower or of the upper extremities (as in our case), has occasionally been seen in persons with otherwise typical achondroplasia (Dufour,[19] Silfverskiöld,[20] Siegert,[21] Porak,[1] Valente and Hoeppner,[22] Grudzinski).[23]

2. A relation of the lesion of the cord to the skeletal anomaly, the tight spinal canal, was probable, in view of the similarity of occurrence and likeness of the operative picture in this case to the anatomic conditions observed in earlier cases. From previous experience, also, the level of compression was to be expected at the site of development of osteoarthritis of the intervertebral joints, i e., just above the wedge-shaped vertebra, where osteophytic formation had been visualized in roentgenograms (figs. 10 and 11).

3. As to the cause of the present severe pain, no unequivocal explanation could be offered, but the acute appearance after a sudden strain suggested trauma to the operative area, possibly with an intraspinal hematoma. Owing to the virtual absence of a subarachnoid and epidural space, a hematoma would be under high pressure and in this way might account for the severe pain.

In these circumstances, there was no doubt that decompressive laminectomy had been indicated in the first place and that it had led to relief of symptoms. But the operation had probably not been extensive enough, because it did not extend up to the level of osteophytic formation at the twelfth thoracic vertebra, where, in all likelihood, maximum constriction of the spinal canal and the actual site of the (partial) block occurred. A second operation, with upward extension of the laminectomy, was therefore suggested.

The patient's pain subsided gradually on rest in bed. He required about three injections of meperidine hydrochloride (100 mg.) a day until September 1, but thereafter needed only one or two injections a day; he got out of bed on

19. Dufour, H.: Achondroplasie partielle, forme atypique, Nouv. iconog. de la Salpêtrière **19**:133, 1906.

20. Silfverskiöld, N.: Sur la question de l'achondroplasie atypique, Acta radiol. **5**:223, 1926.

21. Siegert, F.: Der chondrodystrophie Zwergwuchs, Ergebn. d. inn. Med. u. Kinderh. **8**:64, 1912.

22. Valente, A., and Hoeppner, D. L.: Un caso de achondroplasia parcial, Rev. Assoc. paulista de med. **12**:51, 1938.

23. Grudzinski, M.: Sur l'achondroplasie atypique, Rev. neurol. **34**:678, 1927.

September 2 and was discharged to the neurologic clinic a week later, as he refused to undergo another operation at that time.

Three weeks later, on September 30, the patient was readmitted to the neurologic and neurosurgical service (Cornell) "for further laminectomy." He again complained of recurrent severe pain in the lower part of the back and the left hip, unsteadiness of gait, increasing urinary urgency and incontinence and impotence. Neurologic findings on the third admission were essentially the same as on the first. There was also tenderness over the region of the laminectomy and over the upper course of the left sciatic nerve. Spinal puncture was again attempted on October 8 and October 13 at the laminectomy level (third to fifth lumbar). It was unsuccessful, although the patient felt radicular pains shooting down the legs. The manometer, filled with saline solution, showed no changes on straining or pressure on the jugular vein. Roentgenograms of the spine showed a large amount of residual iodized oil (injected on June 11) scattered within the thoracic and lumbar portions of the spinal canal. Since all the iodized oil had not accumulated in the dependent portion of the spinal canal, the interpretation of these roentgenologic findings was that arachnoidal adhesions and narrowing of the spinal canal had largely obliterated the subarachnoid space.

On October 20 a second operation was performed, with the diagnosis of achondroplastic spine and atresia of the spinal canal.

The operation (Dr. J. L. Pool) consisted in extensive decompressive laminectomy (twelfth thoracic to first sacral vertebrae), with marsupialization of the dura. It was extremely difficult to dissect the fibrosed tissues from the dura at the site of the previous laminectomy, owing to the narrow space available and the extreme lordosis. The lumbosacral portion of the spine formed a right angle (as seen in the roentgenograms). The block of the spinal fluid extended up to the twelfth thoracic segment. Jugular compression demonstrated absence of block when the decompression was completed. The nerve roots of the entire cauda equina were tightly packed into the small spinal canal. This, together with the low grade arachnoiditis, seemed to be responsible for the block. In order to provide maximal and lasting decompression, the dura was sutured to the paravertebral tissue on each side.

The postoperative course was smooth from the second day on. After the sixth postoperative day, the pain in the back and legs decreased considerably; the patient got out of bed on the ninth day, at which time he had no complaints. Neurologic examination revealed nothing noteworthy except for a Laségue sign on each side. The patient regained complete bladder control. His walking improved steadily; he slept well, without any medication, and he was discharged on October 21, one month after the operation, free of symptoms.

Four months later, he was perfectly well, walked without a cane and offered no complaints to questioning. He has not been seen since.

Summary.—An achondroplastic dwarf, aged 30, suffered from pain in the lower part of the back, of increasing severity, which radiated into the legs; unsteadiness of gait; urinary incontinence, and sexual impotence, of about one year's duration. There were no definite objective motor or sensory changes. Roentgenograms showed a moderate wedge-shaped deformity of the twelfth thoracic vertebra and marked osteophyte formation between the eleventh and the twelfth thoracic vertebrae. There were signs of spinal block on spinal puncture and of narrowing of the spinal canal on myeloscopy. Laminectomy

from the third to the fifth lumbar vertebra brought moderate, but transient, relief. Reoperation four months later, with extension of the laminectomy upward to the twelfth thoracic vertebra, was followed by complete and permanent cessation of symptoms. At the operation, extreme narrowing of the spinal canal; absence of a subarachnoid space and crowding of the cord, membranes and nerve roots in the constricted canal, and complete block at the twelfth thoracic level were encountered.

GENERAL SUMMARY

A review of the literature, discussion of previously observed cases and the observation of a new case indicate that lesions of the cord are not infrequent in achondroplastic adults. They are related to the congenital narrowness of the spinal canal, which just accommodates the cord, to the virtual exclusion of the subarachnoid and epidural space. A dorsolumbar kyphosis of varying degree (due to a wedge-shaped deformity of one or two vertebral bodies between the twelfth thoracic and the second lumbar, which is typical of the achondroplastic spine) predisposes to localized osteoarthritis with osteophyte formation above the deformed vertebra. The osteophytes encroach on the constricted spinal canal and give rise to compression of the nutritive vessels and/or the nerve roots, with symptoms of root pain and/or progressive paraplegia. Early recognition of the connection between the lesion of the cord and the underlying skeletal anomaly permits effective and relatively simple treatment, namely, decompression laminectomy. It is imperative to extend the laminectomy above the malformed vertebra, to reach the level of the osteoarthritic osteophyte formation. This is especially important when there is no sensory level to indicate the exact site of the lesion.

A case is reported illustrating the points outlined. Without laminectomy progressive compression of the cord with eventual paraplegia appears inevitable in such cases. In our case the effect of the laminectomy was particularly prompt and gratifying, probably because it was done before any irreversible lesion of the cord had developed.

In achondroplastic infants, the entire chain of unfortunate events may be avoided by the institution of orthopedic measures before the child assumes the upright position. In this way compensation of the dorsolumbar kyphosis may be promoted and formation of a gibbus prevented. There may well be living today, perhaps in institutions, paraplegic achondroplastic dwarfs who are regarded as incurable. While they might have been saved by early operation, it is possible that some may still be benefiited by decompression laminectomy.

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MEASUREMENT OF SENSATION

I. Vibratory Sensation

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LEONA KOPECNY, B.S.

AND

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With the assistance of Paul M. Kohn, M.D., and Helen Reisman, B.A.

CLEVELAND

THIS PAPER is one of a series on sensation and its measurement. In recent years some progress has been made in analyzing the phenomenon of vibratory sensitivity (pallesthesia) by the use of the pallesthesiometer, an instrument more accurate than the tuning fork, and one which enables the clinician to obtain quantitative and qualitative data.

There is no agreement as to what physiologic factors underlie the phenomenon of the appreciation of vibratory stimuli except that it is generally believed that the integrity of certain neural pathways is essential. Fox and Klemperer [1] pointed out that the vibratory sense is not dependent on tactile nerve endings in the skin, an observation demonstrated by the appreciation of vibratory stimuli despite anesthetization of the skin. Proprioceptive receptors, likewise, cannot play the sole role, since patients who show severe impairment of the vibratory sense occasionally preserve their sense of position. Dual receptors at least must be postulated. Fox and Klemperer expressed the opinion that the vibratory sense should be thought of as a "functional form of elaboration of the touch, pressure and position senses."

Although the ability to appreciate vibration undoubtedly depends on the capacity to perceive repetitive tactile and pressure sensory stimuli, it should also be borne in mind that the pallesthesiometer is essentially an acoustic instrument, the frequencies employed being well within the auditory range. Consequently, when the threshold of the appreciation of vibration is determined over various parts of the body, the effect is to measure the ability of the subject to detect sound waves

Sponsored by a grant from the Whitehall Pharmacal Co., New York.

From the Department of Pediatrics, Western Reserve University, and the Department of Contagious Diseases, City Hospital.

1. Fox, J. C., Jr., and Klemperer, W. W.: Vibratory Sense: Quantitative Study of Its Threshold in Nervous Disorders, Tr. Am. Neurol. A. **67**:171-177, 1941.

by means of an extra-aural mechanism. One could reasonably expect that any drug that would affect the auditory threshold would also affect the threshold of vibration. Such drugs are sodium salicylate and quinine, as reported by Falbe-Hansen.[2]

It was our purpose in the present experiments to determine whether nonopiate analgesics would have any effect on the thresholds of vibratory sensitivity. There is disagreement as to whether nonopiate analgesics have any effect on vibratory sensitivity. Wikler and associates,[3] using a Roth neurometer, found that therapeutic amounts of analgesic agents, morphine sulfate, codeine phosphate, acetylsalicylic acid (as much as 1.8 Gm.), ethyl alcohol (95 per cent) and a barbiturate (evipal® [N-methylcyclohexenyl methylmalonylurea]) would not alter the threshold for perception of touch, vibration, hearing, smell and two point discrimination. It was certain to us, however, from unpublished experiments on neurologic disorders with involvement of vibratory sensitivity, that the tuning fork had its limitations, and that an instrument of the kind described here disclosed changes not suspected or demonstrable with a tuning fork.

METHODS AND MATERIALS

The pallesthesiometer used in these studies, and called the biosthesiometer®,[4] was first described by Aring and Frohring[5] and included alterations described by Frohring and associates,[6] and subsequently modified to meet the objections of Gregg and Toomey,[7] so that it was possible to extend the range of the instrument to a lower amplitude. It can be shown that with the particular vibrator used the amplitude of the vibrator button is proportional to the square of the applied voltage. For this reason, a comparison of readings made in terms of the square of the applied voltage gives a ratio directly proportional to the amplitudes of vibration, which later can be measured in percentages of change. In these tests, V^2 units were used as a measure of the amplitude of vibration of the vibrator button.

Each experiment was performed as follows: The subject was put to bed; after a few minutes' rest, a test point was marked with ink on the skin over

2. Falbe-Hansen, J.: Clinical and Experimental Histological Studies on Effects of Salicylates and Quinine on Ear, Acta oto-laryng. (supp.) **44**:1-216, 1941.

3. Wikler, A.; Goodell, H., and Wolff, H. G.: Studies on Pain: The Effects of Analgesic Agents on Sensations Other Than Pain, J. Pharmacol. & Exper. Therap. **83**:294-299, 1945.

4. This instrument may be obtained from the Bio-Medical Instrument Company.

5. Aring, C. D., and Frohring, W. O.: Apparatus and Technique for Measurement of Vibratory Threshold and of Vibratory Adaptation Curve, J. Lab. & Clin. Med. **28**:204-207, 1942.

6. Frohring, W. O.; Kohn, P. M.; Bosma, J. F., and Toomey, J. A.: Changes in the Vibratory Sense of Patients with Poliomyelitis as Measured by the Pallesthesiometer, Am. J. Dis. Child. **69**:89-91 (Jan.) 1945.

7. Gregg, E. C., Jr., and Toomey, J. A.: Measurement of Sensation: II, Ann Arbor, Mich., Edward Brothers, Inc., 1949.

the anterior surface of the right thigh, one third of the distance from the middle of the patella to the greater trochanter, except when otherwise noted. The vibrator button was then applied to the test point, the full weight of the vibrator applicator (15 ounces [424 Gm.]) being allowed to rest on the surface. In order to prevent variations of pressure from experiment to experiment, no further pressure was used. The operator then gradually increased the amplitude of vibration until the subject first became aware of the vibration of the vibrator button. It is important to have the subject understand definitely what is wanted and to have him realize the exact time he first becomes aware of the vibration.

The first reading is usually askew, and it is only when the subject realizes what is wanted and the readings have become consistently similar, that is, within a few points of each other in dial readings, that normal readings may be plotted. The reading at this point, in V^2 units, was called the "threshold value." This procedure was checked several times, rest periods being allowed between readings. In this way, the value of the control threshold was finally established. The drug to be tested was then administered, and subsequent threshold readings were noted. The percentage increase (or decrease) in threshold for each reading was then computed, and time action curves, similar to those used by Wolff, Hardy and Goodell,[8] were constructed. All the test subjects were adults (nurses, medical students and physicians) between the ages of 18 and 30 years. The present experiments, therefore, constitute a "before" and an "after" effect.

Temperature observations on the room in which the tests were made were carefully controlled; although the test room was not air conditioned, the average mean varied but little and had no effect on the subject being tested unless all windows and doors were closed and the temperature was deliberately elevated by electric heaters. This was not a factor in our experiments.

The maximum height of the threshold-raising action for vibration sense was obtained from the highest point or level of each time action curve within a certain period, usually at the end of a thirty or a sixty minute period. The effective period of the analgesic drug is the time elapsed between the administration of the drug and the return of the threshold to the preadministration level. This was not always determined.

Some subjects gave variable reactions, the interpretation of which was difficult. Imponderable factors had to be considered, factors which affected the subject, such as noise, excessive heat, objective distractions and such subjective conditions as inattention, sleeplessness, tiredness and psychic disturbances. A combination of physical exhaustion associated with a planned temperature increase gave a pronounced rise in threshold value. There may be other objective disturbances which, in certain circumstances, cause the observer himself to have lapses of attention or straying, especially when thinking of extraneous and interesting things. The first observation, therefore, is rarely accurate, being far above or below the base line as compared with subsequent observations. Again, too, a subject observed for a great length of time, six hours for instance, may become bored and inattentive, and the responses therefore will be less accurate. Most subjects are poor material for long-continued, careful observation. The subject's mind wanders; he may think about other things of interest to him, and inattention results, with all its attending inaccuracies.

The method of calculation is contained elsewhere.[7] Only when the subject became settled and readings became consistent and approximately the same for

8. Hardy, J. D.; Wolff, H. G., and Goodell, H.: Pain Threshold in Man, in Glasser, O.: Medical Physics, Chicago, The Year Book Publishers, Inc., 1944, pp. 901-905.

at least six chance readings were these readings taken for pretest threshold values. Since, in this instance, the initial reading was rarely consistent with the many subsequent readings, it was discarded. If, for instance, there was a change in either direction from several previous test values, more readings were taken until the subject was stabilized. At times, the subject had to be dismissed if it became apparent that he was physically, but not mentally, present. The voltage square readings for each of the agreeing tests were averaged, therefore—for the ten minute reading, 301 V^2; for the twenty minute reading, 317 V^2.

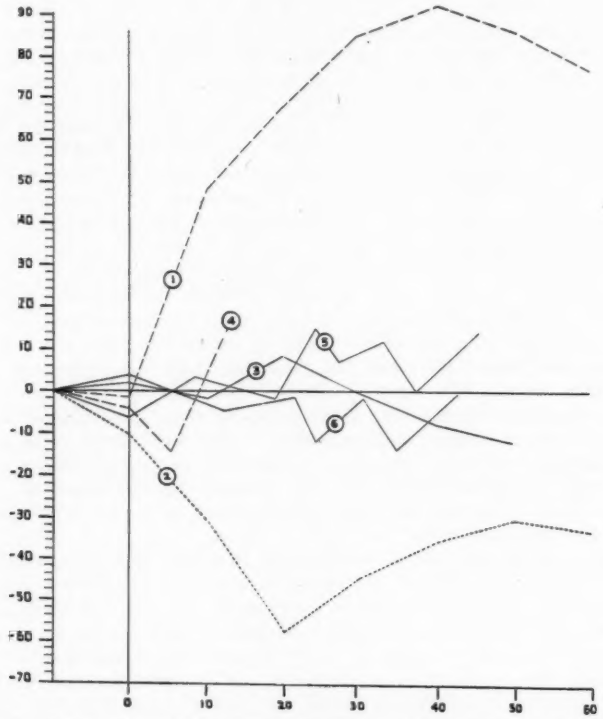

Fig. 1.—Types of sensitivity responses. The positive reaction is indicated by a line of dashes (*1* and *4*); the reversal, or negative, reaction, by a line of short dashes (*2*) and a normal reaction by a solid line (*3, 5* and *6*).

Three subjects who for some reason, psychic or otherwise, could not come to a persistent pretest level, were excluded. We allowed more latitude in determining control values in some of our initial experiments, so that variations might be plotted above and below the line in points removed which were not over 15 percentage points, in one way or the other, but which, in summation, might be over 15 percentage points. Subsequently, we adopted the plan of waiting until the subject was stabilized and began to give nearly comparable readings, i.e., within a few dial readings of each other, before the experiment was begun.

In the interpretation of results, the following points were observed:

A positive reactor was a subject who had a reaction at least 15 percentage points above the normal control line. A reverse, or negative, reactor was a subject who had at least a 15 point dip below the average line. A normal response was a reaction which showed a change of not more than 15 points, all the readings being above the line, or a reading in which the combined points above and below the line did not amount to a change of more than 15 points.

If a subject was in the negative zone, for instance, and had a — 15 point reading, and the next, or some subsequent, reading was + 15 points above the base line, a positive response could be assumed, because after therapy there would be at least 30 points of difference in the reaction. The reverse would be true; that is, if a subject started with a positive response above the line, for example, a + 15 reading, and responded immediately so that the reaction was — 15, the result would be considered a negative response. There were exceptions in which the tests were made over the right forearm and the side of the forehead—exceptions so great that conclusions could not be drawn—and the remarks here apply only to tests made over the area of the quadriceps (type of reaction, chart 1).

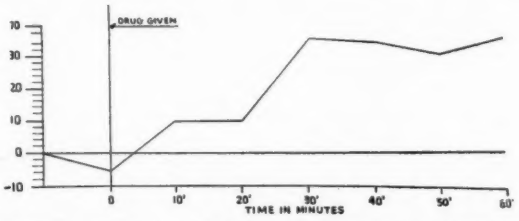

Fig. 2.—Composite curve for preliminary observations on 10 subjects, showing the effect of 15 grains (1 Gm.) of acetylsalicylic acid on sensitivity over the area of the right quadriceps rectus muscle.

Prior to the final tests, the subjects used were tested several times, and an average was determined which became the zero line from which departures were computed. Their readings could then be compared each with the other.

EXPERIMENTAL RESULTS

Our initial tests were made with the commonest of analgesics, acetylsalicylic acid (15 grains, or 1 Gm.). Since this study was a preliminary and path-finding effort to establish technics, the methods of initial observation were slightly different, as already indicated. The average of the values, for at least six readings, was plotted on the zero percentage line. If this was 172 V^2 and the readings for the twenty minute period, after administration of acetylsalicylic acid, was 192 V^2, the difference would be 20 V^2, or 11 per cent, the latter constituting the reading for the twenty minute period.

Of the subjects tested, all 10 had positive reactions, sensibility being diminished after the drug was given; 2 of the 10 gave only slightly positive responses.

The threshold was significantly greater after the drug was given than before. Although the readings in the original experiments showed positive reactions in all instances (chart 2), such successful results had obviously to be modified when stricter attention was paid to the original normal testing period. Subsequent figures could be stated as being more representative of the various experiments.

In the next experiment, we observed the reactions to acetylsalicylic acid over a period of three hours, after a preliminary set of normal observations over a duration of one hour. Ten subjects were tested. Seven gave a definite positive reaction and 3 a normal response, the threshold again being significantly greater after the drug was given than before. It was noted that the change began after twenty minutes and that some effect was still noticeable after two hours of observation (chart 3).

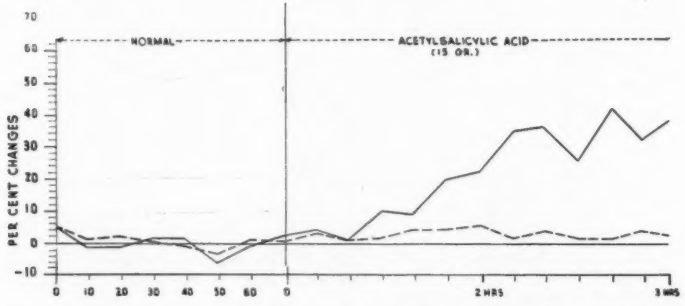

Fig. 3.—Observations in sensitivity tests for three hours after administration of acetylsalicylic acid. The solid line shows positive readings for 7 subjects, and the line of dashes, average readings for 3 subjects giving a normal response.

Because the response had not returned to normal after two hours, subjects were given acetylsalicylic acid and studied over a period of five hours, the pretest threshold readings running for sixty minutes. The total period of observation covered six hours. The initial, or acclimatization, readings were discarded. Eight of the subjects had a positive reaction. One with a normal response had a reversal, followed by a late positive response (chart 4).

Up to this time, all tests had been made over the area of the right quadriceps muscle. The next tests were made on the same subjects but over different points: (1) over the right quadriceps, as usual; (2) over the right forearm, and (3) over the middle of the forehead.

Ten such subjects—doctors and nurses—were used in this experiment: 10 persons who could be tested on different days at various points with the same medication and with the same operator testing.

Of the 10 subjects tested over the quadriceps area, 7 had positive reactions, 1 gave a normal response and 2 had reversals. One reversal may have been questionable, since it occurred so late in the course of the experiment, and in a subject with unstable reactions generally. For the sake of simplicity, we included it among the reversals.

As previously stated, the same persons were tested over the right forearm. Only 4 of these subjects had positive reactions, and these positive reactions were peculiar in that they occurred in 3 instances only after a previous negative reaction had been recorded. In fact, there was only 1 subject who had a clearcut positive reaction, and that at a late period. Three subjects had negative reactions and 5 had a normal response. We do not have any explanation as to why the area over the right forearm was less sensitive.

The factors all remained the same in the next experiment except that the same 12 subjects were tested over the center of the forehead.

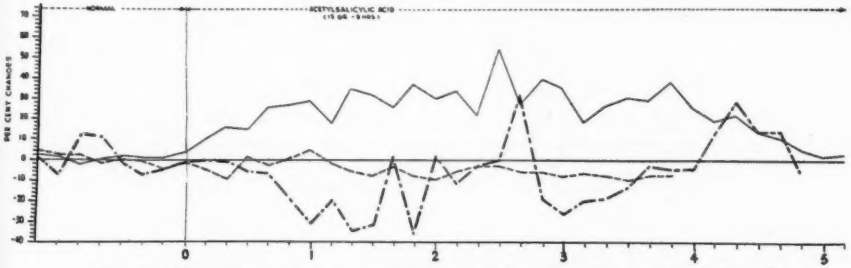

Fig. 4.—Observations for six hours after administration of acetylsalicylic acid. Values for subjects with positive responses are shown by the solid line; the value for the subject with a normal response, by a line of dashes, and the value for the subject with a reversal, by a faint gray line.

Here, it was difficult for the subject to discern at times the difference between what he heard and what he felt. End points were not accurately appreciated, even in the controls. There were, however, some positive reactors about whom comment must be made. Seven subjects had positive reactions which were not clearcut, for 3 gave them late and 1, who had a primary positive reaction, had a late negative reaction. Three subjects had a normal response, and 2 obviously had a negative reaction. In comparing the results for the three areas —quadriceps, forearm and forehead—it was obvious that the best spot to test was over the right quadriceps area.

Our preliminary tests showed that the biosthesiometer could pick up slight differences in vibratory sensitivity, and about 30 subsequent subjects, tested at various points over the body and at prolonged intervals, gave similar reactions. Roughly, 60 to 70 per cent of the subjects tested showed positive reactions.

Fifty subjects were then tested to determine whether we would always get the same relative proportion of positive reactions. Our objective this time was to find out how many subjects of a chance number tested, given acetylsalicylic acid, showed positive and how many reverse or normal, reactions. Fifty such subjects were used and the averages computed. Thirty-four, or 70 per cent, gave positive reactions; 2, or 4 per cent, had reversals and 12, or 12 per cent, gave a normal response. One subject was excluded, since he could not become oriented. This result was similar to that obtained in the preceding experiments (chart 5).

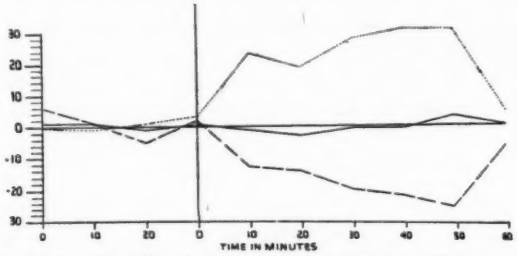

Fig. 5.—Responses for 50 subjects given acetylsalicylic acid over an observation period of one and one-half hours. Average values for subjects with positive responses are shown by the line of dots; values for subjects with reversals, by the line of dashes, and average values for subjects showing normal responses, by the solid line.

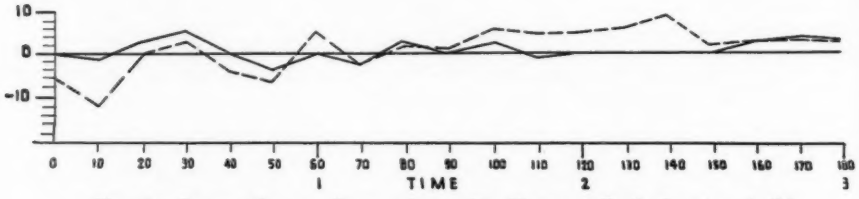

Fig. 6.—Comparative readings, taken with Henny pallesthesiometer (solid line) and the Frohring biosthesiometer (line of dots) for 10 subjects.

Laidlaw and Hamilton used a Henny pallesthesiometer in their experiments. A comparison of the Henny pallesthesiometer and the Frohring biosthesiometer was made on subjects studied over a period of three hours. Laidlaw loaned us the original Henny instrument, which he had used. Our interest in this instrument lay in its having been used by several investigators and its well appreciated efficiency. It was important, then, for us to have comparative data, particularly since the Henny instrument operates at one-half the frequency of the biosthesiometer, a fact which gave us an opportunity to compare instruments of different frequencies. The Henny instrument is subject to change

in line voltage, as it does not provide a means by which it may be standardized. The two instruments also registered nearly comparable changes in the reading after acetylsalicylic acid had been given. The composite graphs obtained for 10 normal subjects were in fair agreement (chart 6).

COMMENT

It is hard to explain the opposing results of Wikler and associates,[3] especially since the limit of their doses was 1.8 Gm., as compared with our dose of 1 Gm. of the test drug, until it is realized that observations were made with a less sensitive instrument and then on only 6 subjects. In our experiments with hundreds of test observations recorded here (with others done subsequently), it could be stated with certainty that the biosthesiometer picks up fine vibratory responses, and that if an area over the quadriceps rectus is tested it can be used as a measure of vibratory sensitivity. If 60 per cent or more of average subjects show a definite response, it should be permissible to test out and detect such sensitive persons and to use them as subjects in testing the effect of analgesic drugs on the vibratory threshold. Actually, of 123 subjects tested (presently reported), 81, or 66 per cent, had positive reactions; 16, or 12 per cent, reversals, and 26, or 21 per cent, normal responses.

CONCLUSION

The biosthesiometer measures the threshold for appreciation of vibration.

Acetylsalicylic acid raises the threshold for appreciation of vibration in 66 per cent of the subjects tested. The reversal was consistent at most of ten subsequent trials, or at least there was but slight response.

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SURGICAL TREATMENT OF SCIATICA

Results Three to Eight Years After Operation

DEAN H. ECHOLS, M.D.
NEW ORLEANS

A RECENT development of interest to neurologists is the almost complete disappearance of a previously common diagnosis, namely, neuritis of the sciatic nerve. Although toxic and infectious neuritides of the sciatic nerve exist as extremely rare conditions, the common painful state formerly called chronic, or recurrent, sciatica is now known to be the result of compression of a nerve root within the spinal canal or its foramen. It is also known that such sciatic pain is due to compression of the root by a diseased intervertebral disk in at least 75 per cent of cases. In the rest, compression of the root is produced by such pathologic conditions as intraspinal tumor or cyst, primary or metastatic tumor of a vertebra, spondylolisthesis and arthropathy.

Although the discovery that most sciatic pain is due to an intraspinal lesion has proved a boon to mankind, several details of therapy are still in the controversial stage. The chief point of contention concerns the type of surgical treatment in the case of ruptured intervertebral disk. Many neurosurgeons are of the opinion that the compressed nerve root should be decompressed, that the offending disk should be partially removed and that spinal fusion should not be performed. On the other hand, an increasing number of orthopedists are advocating some type of internal fixation of the spine at the time of removal of the disk.

This combination of decompression of the root, removal of the disk and spinal fusion is known as the combined operation for ruptured disk. It is contended by many proponents of this operation that pain in the back, which constitutes a major part of the syndrome of ruptured disk, is more likely to disappear if the combined operation is performed. It is also argued that the bone graft prevents further disintegration of the diseased disk and consequently decreases the number of secondary operations for recurrence of the sciatic pain.

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Advocates of the combined operation for ruptured disk have extended the indications for the procedure to include such factors as the presence of associated anomalies of the lumbosacral region, unstable spine or arthritis; roentgenographic evidence of pronounced narrowing of the disk; predominance of pain in the back over sciatic pain; occupations requiring lifting and bending, and pain in the back of long duration. Some have gone so far as to recommend the combined operation for practically all patients requiring surgical removal of lower lumbar intervertebral disks.

Like most neurosurgeons who have cooperated with orthopedists in the management of chronic sciatic pain, I have collaborated without comment at the combined operation whenever it has been recommended by the orthopedist. When, after ten years' experience with the simple operation for ruptured disk and, to a reasonable extent, with the combined operation, my orthopedic colleagues and I realized that we had acquired no convictions regarding either the need of or the indications for the combined operation, we decided to make the follow-up study the results of which are reported here.

POSTOPERATIVE STUDY

Material.—A follow-up study was made on a series of 151 patients, which comprised all the private patients with a preoperative diagnosis of ruptured lumbar disk who had primary intraspinal exploration during the five year period ending Dec. 31, 1944. Actually, the only patients with the syndrome of ruptured disk excluded from this study were those who had had previous spinal operations elsewhere. All surgical procedures except the spinal fusions were performed by me. The only operative death in the entire series occurred as a result of pulmonary embolism, several days after a combined operation.

Of the 151 patients, 109 had ruptured disks which were found at operation and partially removed (table 1). The term partial removal is used because there is no such operation as total removal of a disk. Eight patients had the combined operation (removal of ruptured disk and spinal fusion). Six patients had spinal fusion only, exploration revealing no lesion of the disks. Most of the last group had chronic pain in the lower part of the back without real radicular pain, and the disks were inspected chiefly as a precaution. In 9 patients exploration showed normal disks. Fourteen patients had a lesion of some other type, such as metastatic carcinoma, which explained the symptoms. Five patients may have had a ruptured disk, but exploration was incomplete. In 2 of these patients, exploration was abandoned because of uncontrollable bleeding, and the suspected root was sectioned. In the other 3 patients a bulging disk was revealed but not opened, the operator being content with decompression of the root in 2 cases and rhizotomy in 1 case.

The 28 cases in which exploration was incomplete or revealed a normal disk and a causative lesion other than ruptured disk form the subject of a separate report. The 14 cases of combined operation will be included in a study of spinal fusion, to be reported by others. The present review is concerned only with the 109 patients with ruptured disk treated by partial removal of the disk.

Method.—In order that we might obtain an unbiased evaluation of the results, Dr. William Sheppard, an orthopedist, was invited to make the follow-up study, since he had had no previous contact with this group of patients. Incidentally, before the study, he was a conservative advocate of the combined operation for ruptured disk. He examined all patients, evaluated the data from questionnaires and classified the patients according to their operative results.

The longest follow-up period was 7.9 years, and the shortest was 2.9 years. The average interval was 5.5 years.

Seventy-five of the 109 patients returned to furnish the interval history and for orthopedic examination and roentgenograms of the spine. Twenty-three were unable to return but answered a questionnaire.

"Have you been relieved of the pain for which your operation was performed?
"Have you any pain in your back? If so, please describe.
"Have you any pain in your legs? If so, please describe.
"Are you able to do the same work you did before the pain in the leg or back started?
"Have you had any operations on your back since the disk operation performed by Dr. Echols? If so, when and where.
"Have you had any other illness which interferes with your ability to work?
"Please list a few things you can do without serious discomfort.
"Please list a few things you know you are unable to do because of the pain in your back or leg."

TABLE 1.—*Classification of 151 Cases of Sciatica*

Classification	No. of Cases
Verified ruptured disk, which was removed	109
Combined operation (8 with partial removal of disk)	14
Negative exploration for ruptured disk	9
Incomplete removal of disk	5
Other lesions, such as tumor	14
Total	151

Three are known to have died. Eight could not be traced. A study of the records of the last group, including the early follow-up correspondence, disclosed no reason to suspect that the results would differ from those of the group which was kept under observation.

The following data are derived from the 101 cases in which a follow-up report was obtained (75 examinations, 23 questionnaires and 3 nonoperative deaths). Seventy-seven per cent of the patients were men, between the ages of 17 and 59 years, and 23 per cent were women, between the ages of 21 and 58 years. The average age for the entire group was 38.1 years.

Observations.—Trauma: Only 57 per cent of patients attributed their symptoms to a specific injury. The absence of history of injury for many patients is consistent with the commonly accepted theory that intrinsic lesions of the disk make them vulnerable to moderate trauma.

Disk Affected: Fifty-one of the lesions were of the lumbosacral disk, and 50 were of the adjacent disk. There was no instance of rupture of the third lumbar disk, but we have had a few cases of such a lesion in the years before and after the period covered by this series. More surprising is the absence of multiple ruptured disk in this series. This

suggests the possibility that lesions were overlooked in the 3 patients in the group with unsatisfactory results on whom a second operation was not performed.

At the time of operation, each lesion was classified as a nodule on the disk, as a bulging disk without overlying veins or as a loose sequestrum from the disk. There were 63 cases of nodules, 17 of bulging disk and 21 of sequestrums. Some of the sequestrums may have been nodules which ruptured during operation.

The surgical treatment consisted of decompression of the affected root by unroofing it with chisel or rongeur, removal of the protruding portion of the disk and extensive curettage and removal of inner portions of the disk. In addition to partial removal of the ruptured disk, section of the sensory fibers of the affected root was performed in 6 cases. The fact that in 5 of these cases operation was performed in the early part of the study (1940) indicates that I found section of the sensory root unnecessary in typical cases of ruptured disk. However, rhizotomy was performed extensively in the group of cases of lesions other than ruptured disk.

Myelographic Findings: This study did not contribute any worth while information regarding the value of myelography, for it was discontinued as a routine diagnostic procedure about Jan. 1, 1941. Since then, it has been used in cases in which signs and symptoms of rupture of the fourth or the fifth lumbar disk were not quite typical but operation for the lesions was contemplated.

CLASSIFICATION OF RESULTS

The functional results were tabulated as excellent, satisfactory or unsatisfactory. Results were considered excellent when the patient was in complete agreement with the examiner that there was no disability resulting from the original pain in his leg or back or from the operation performed. Results were classed as satisfactory when the patient, in spite of minor difficulty with his back or leg returned to working full time without disability. The results were unsatisfactory when the patient could not work full time because of persistence or recurrence of pain in the back or leg.

Six patients for whom results were excellent or satisfactory were relieved of the symptoms from twelve to sixty-six months after operation (average, forty months) and then were operated on a second time for recurrence of pain in the back and leg. Three had sciatica on the opposite side owing to rupture of an adjacent disk; 2 had sciatica on the opposite side owing to another nodule on the same disk, and 1 had recurrence of the original sciatica because of adhesions which compressed the root and was treated by rhizotomy. All 6 patients were restored to the classification of satisfactory or excellent results

and have remained there for periods ranging from six to sixty-eight months (average, thirty-seven months).

Three patients eventually had spinal fusions because of failure to obtain relief from the pain in the back; although they were relieved of symptoms, the results were classified as unsatisfactory because relief was obtained by spinal fusion and not by a neurosurgical procedure. Of the 4 others who are still classified as showing unsatisfactory results, 1 presents a complex psychiatric problem, and 3 may have another ruptured disk which explains their partial disability. All 4 are active but are uncomfortable at times and are not regularly employed.

Of the 3 patients who died (ten months, four years and five years after operation), 2 were classified at the time of death as having an unsatisfactory result and 1 as having a satisfactory result. Deaths were due to suicide, an automobile accident and an unknown cause, respectively.

TABLE 2.—*Combined Results of 101 Operations for Sciatica After Five and One-Half Years*

Follow-Up Study	No. of Cases	Results: Excellent		Satisfactory		Unsatisfactory	
		Cases	Percentage	Cases	Percentage	Cases	Percentage
Examined	75	34	45.33	34	45.33	7	9.33
Questionnaires	23	13	56.52	10	43.48	0	0.0
Known dead	3	0	0.0	1	33.33	2	66.66
Total	101	47	46.53	45	44.55	9	8.92
		Good Results, 91.08%					

Of the 23 patients traced by questionnaire, excellent results were obtained in 56.52 per cent and satisfactory results in 43.48 per cent; there were no unsatisfactory results.

A preliminary report on the results in the group of 75 patients (81 neurosurgical operations) who returned for examination has already been made by Caldwell and Sheppard.[1] In their report, the results were correlated with such factors as associated anomalies of the spine, postoperative narrowing of the disk and postoperative hypertrophic changes. The authors concluded that "there are no criteria for spinal fusion following removal of a protruded nucleus pulposus."

The combined results for the 75 patients who returned, the 3 who are known to be dead and the 23 who answered questionnaires were as follows: Forty-seven had excellent results; 45, satisfactory results, and 9, unsatisfactory results (table 2). Since these results (satisfac-

1. Caldwell, G. A., and Sheppard, W. B.: Criteria for Spinal Fusion Following Removal of a Protruded Nucleus Pulposus, J. Bone & Joint Surg. **30**: 971-980 (Oct.) 1948.

tory or excellent in 91 per cent) are somewhat better than those in most reports,[2] an explanation should be sought. The major factor seems to be the careful selection of cases for operation which resulted from our policy of making mandatory orthopedic study and conservative treatment before operation. It should also be stated that some of the patients regarded by our orthopedists as having a ruptured disk were not accepted for surgical treatment because the symptoms were considered too atypical.

In view of such satisfying results in a group of 101 patients, my orthopedic colleagues and I are of the opinion that spinal fusion should not be performed at the time of removal of the disk except in rare circumstances. This conclusion has resulted in a definite change in our procedure; 18 per cent of the patients with ruptured intervertebral disk in 1947 had the combined operation.

RELATION OF RESULTS TO OCCUPATION

An attempt to correlate the results of operation with the patients' occupations proved difficult. A few truck drivers, oil field workers and refinery workers changed to lighter jobs after operation, whereas office workers, housewives and professional people did not change occupations. Of the 7 living patients classified as having had an unsatisfactory result, there were 2 office workers, 1 waitress, 1 undertaker, 1 laborer, 1 welder and 1 boiler maker.

The cases of 18 patients, or 17.8 per cent, were classified as compensation cases. In this group, excellent or satisfactory results were obtained in 78 per cent and unsatisfactory results in 22 per cent.

RATE OF RECURRENCE

Of the 45 patients operated on during the first half of the five year period, about 9 per cent (4 patients) were operated on for recurrence

2. Friberg, S., and Hirsch, C.: On Late Results of Operative Treatment for Intervertebral Disc Prolapses in the Lumbar Region, Acta med. Scandinav. **93**: 161-168, 1946. Barr, J. S.: Ruptured Intervertebral Disc and Sciatic Pain, J. Bone & Joint Surg. **29**:429-437 (April) 1947. Lenhard, D. B.: End-Result Study of the Intervertebral Disc, ibid. **29**:425-428 (April) 1947. Love, J. G.: The Disc Factor in Low Back Pain With or Without Sciatica, ibid. **29**:438-471 (April) 1947. Marble, H. C., and Bishop, W. A.: Intervertebral Disc Injury: Anaylsis from an Industrial Standpoint, J. Indust. Hyg. & Toxicol. **27**:103-109 (April) 1945. Campbell, E., and Whitfield, R. D.: Certain Reasons for Failure Following Disk Operations, New York State J. Med. **47**:2569-2573 (Dec. 1) 1947. Shinners, B. M., and Hamby, W. B.: Results of Surgical Removal of Protruded Lumbar Intervertebral Discs, J. Neurosurg. **1**:117-122 (March) 1944. Grant, F. C.: Operative Results in Intervertebral Discs, ibid. **1**:332-337 (Sept.) 1944; Operative Results in Intervertebral Disks, Ann. Surg. **124**:1066 (Dec.) 1946. Spurling, R. G., and Grantham, E. G.: Ruptured Intervertebral Discs in the Lower Lumbar Region, Am. J. Surg. **75**:140-158 (Jan.) 1948.

of symptoms, whereas of those in the last half of the study only about 3 per cent (2 patients) had a second operation. These figures suggest that another 6 per cent (4 patients of the latter group) will eventually have a recurrence. If this deduction is correct, the incidence of recurrence following removal of a ruptured disk can be set at about 10 per cent.

SUMMARY AND CONCLUSIONS

Of 109 patients operated on for proved ruptured disk in the lumbar region, 101 were under observation for an average of 5.5 years. The shortest follow-up period was 2.9 years and the longest 7.9 years. Ninety-one per cent of the patients were classified as having a good result because they were working full time without disability and with no more than minor complaints referable to the back and leg. Since the results of operation for removal of a ruptured disk are so satisfactory in carefully selected cases, the combined operation would seem to be contraindicated except in unusual circumstances.

Ochsner Clinic.

ABSTRACT OF DISCUSSION

Dr. E. G. Grantham, Louisville, Ky.: I shall present slides showing results in a similar series just completed by Dr. R. Glen Spurling and myself. There is a four year gap in the series, so that groups with long and with short term follow-up observations are represented, but the results were essentially the same in the two groups and will therefore be reported together. These results correspond fairly closely with Dr. Echols'. I was somewhat surprised to find that the percentage with relief of leg pain was the same as that of relief from backache. Ordinarily, it is thought that leg pain is completely cured, but this is not true. Both backache and leg pain disappeared entirely in 40 per cent of the group. In 79 per cent the operation was considered entirely successful. In an additional 11 per cent it was considered partially successful. Ninety-seven per cent returned to work, but 12 per cent have had to change their work to a less strenuous form because of the persistence of symptoms.

For the compensation group, the poor results were twice as bad as those for the entire group. We did not perform a spinal fusion in any of the cases, and, so far as we know, none of the patients have had spinal fusions since their original operation. It must be admitted, however, that in the 10 per cent for whom results were not satisfactory fusion may be necessary later. Because of the high percentage of cases in which eminently satisfactory results are obtained with simple removal of the disk alone, spinal fusion should be reserved for cases in which a period of trial has proved that the simple removal of the disk has not been satisfactory.

Dr. George S. Baker, Rochester, Minn.: The symptoms produced by herniation of the nucleus pulposus of the diseased intervertebral disks in the lower lumbar area seem to be well recognized by the average medical practitioner. Spurling and Bradford, Love and Walsh, Mixter and Barr, Keegan and many others have described the syndrome. Unfortunately, a clearcut program of treatment of this condition is not universally accepted. The severe root pain is invariably relieved by simple surgical removal of the herniated tissue. Dr. Echols has not limited his evaluation of the operative cases to the mere relief of "sciatica" but has also

included the question of associated backache in his results. This is often the "bugaboo" in any follow-up study of similar cases, and it is also the reason that many surgeons find it necessary to resort to other surgical procedures.

I do not believe that the best results will be obtained in the treatment of patients with herniated nucleus pulposus when the operative procedure is entirely restricted to simple removal of the herniated portion. Each case must be judged as an individual problem, and medical, neurologic, orthopedic, neurosurgical, and quite often psychiatric, opinions are necessary. My experience in the past ten years started with simply removing the herniated portion of the nucleus pulposus, but today I find that in about 30 per cent of cases of so-called ruptured disk in which operation is required a bone graft of the lumbar portion of the spine is also performed in conjunction with removal of the herniated nucleus pulposus. It is worth mentioning that the results in the classic "combined operation" will be infinitely better when the procedure is completed at the primary operation. Whenever possible, the surgical removal of the offending lesion is considered adequate, but if examination reveals that other procedures may be helpful it is just as harmful to disregard these indications as it is to perform a bone graft in all cases of herniated disk when this is not necessary, and is often detrimental. The proper operation can be applied in the majority of cases, but it is often hard for the patient to adjust himself to the incomplete one. Careful selection seems to be the answer to the problem of better results in the treatment of his major medical problem.

Dr. Dean H. Echols, New Orleans: I asked Dr. Baker to discuss this paper, since this Section ought to hear both points of view. I should have been somewhat reluctant to report this series, with good results in 91 per cent of cases, if I had personally followed and examined the patients and evaluated the results. However, I had nothing to do with the follow-up study and did not see the patients when they returned. The study was conducted by our orthopedists, who at the time of the study were doing spinal fusions on 18 per cent of patients. It is significant that after this study these orthopedists decided to abandon the combined operation except in rare circumstances.

POINT OF ACTION OF 3-O-TOLOXY-1,2-PROPANEDIOL (LISSEPHEN®) AND EFFECTS ON NERVOUS SYSTEM

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CHICAGO

WHILE studying the pharmacologic properties of α-substituted ethers of glycerol, Berger and Bradley [1] observed that certain of these compounds caused paralysis with profound muscular relaxation, and a sleeplike condition from which the animals could be roused. Paralysis was followed by complete recovery. The most potent and the safest of all the compounds examined, and the drug with the widest margin of safety between the paralyzing and the lethal dose, was 3-o-toloxy-1,2-propanediol, the o-tolyl ether of glycerol. It was said to have a curare-like action, but with a greater factor of safety. The drug was suggested by Mallinson [2] as a useful agent in anesthesia. He published his experience and results in 112 cases. He found it to have a greater margin of safety than curare. Doses of 7 to 28 mg. per kilogram of body weight produced no undesirable effects in man. This observation is not unexpected, since 200 to 300 mg. per kilogram is tolerated by animals. Abdominal relaxation was obtainable even in the conscious patient, and without any distress. Mallinson used this drug together with pentothal® to obtain abdominal relaxation. He administered the drug intravenously in doses of 0.4 to 2 Gm. and gave as much as 5 Gm. in divided doses in one long operation without untoward effects.

An agent which might produce muscular relaxation or lessening of spasticity or temporary paresis would prove useful in the treatment of spasms in cases of lesions of the spinal cord, and possibly of poliomyelitis, and in the prevention of injuries during administration of

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The study was aided by a grant from the National Foundation for Infantile Paralysis, Inc.

From the Department of Nervous and Mental Diseases, Northwestern University Medical School.

The drug was furnished by Dr. Richard K. Richards, of Abbott Laboratories. Myanesin is the British drug house's designation for the same substance.

1. Berger, F. M., and Bradley, W.: The Pharmacological Properties of α:β-Dihydroxy-γ-(2-methylphenoxy)-propane (Myanesin), Brit. J. Pharmacol. **1**:265 (Dec.) 1946; Muscle-Relaxing Action of Myanesin, Lancet **1**:97 (Jan. 18) 1947.

2. Mallinson, F. B.: A New Synthetic Curarizing Agent in Anesthesia, Lancet **1**:98 (Jan. 18) 1947.

electric shock, provided that it had an element of safety greater than curare. It was held desirable, therefore, to study the point of action of this substance.

Lissephen® is a colorless, odorless, crystalline solid with a melting point of 70 to 71 C. Berger and Bradley [1] found that injections of 10 to 12 mg. per kilogram of body weight in rabbits produced flaccid paralysis without loss of consciousness. The rabbits regained muscular power five to ten minutes after injection and remained well. Larger doses caused paralysis of longer duration. Doses of 350 mg. were tolerated when injected over a period of thirty minutes. Lissephen® has a low toxicity and a distinct margin of safety.

PRESENT INVESTIGATION

Experiments were undertaken (1) to observe the action of lissephen® on the normal animal, (2) to compare the findings with those of Berger and Bradley and (3) to observe its action on (*a*) the peripheral nerves, (*b*) the spinal animal, (*c*) the decerebrate preparation and (*d*) the cortex and pyramidal tracts.

Normal Animals.—Rabbits: Six rabbits were studied. Thirty milligrams per kilogram of body weight given intravenously caused immediate quadriparesis which lasted five minutes. The animals were awake. The limbs were sprawled out and relaxed.

Cats: Eighteen cats were studied. The typical reactions to the drug are described as follows: Thirty milligrams per kilogram injected intravenously was followed immediately by a condition in which the animal was immobile; it was conscious but showed no interest in its surroundings. It was paretic in all four extremities. The paresis lasted three minutes. In other animals no immediate effect was observed, but after three minutes a previously active cat became inactive and ataxic. The animal was able to right itself, and the patellar reflexes were retained.

When 45 mg. per kilogram was injected intramuscularly, the animal became immobile in four and one-half minutes. The cat lay down, but when prodded would walk a few steps. It righted itself clumsily. Eight minutes after the injection it did not startle to loud noises. Twelve minutes after the injection it was still immobile, was passive when tied to a board and still did not startle to loud noises. The animals recovered in fifteen minutes. When fifteen minutes after recovery an intravenous injection of 70 mg. per kilogram was administered, the following effect was noted: The legs were paretic in two minutes, the paralysis being most pronounced in the hindlegs. There was no effect on the neck or tail. When the animal was forced to

walk, it took two steps and then sprawled, owing to paresis of the hindlegs.

When 55 mg. per kilogram was administered intravenously to cats, the following effect was observed: Respiration became shallow for about two minutes, and then flaccidity, paresis and ataxia appeared in all extremities, being most severe in the hindlegs. When the animal was placed on its back, it fell to the side, with head lagging behind the body. There were no placing reactions, and no tonic, neck or labyrinthine reflexes were elicited. At the end of six minutes paresis disappeared but slight ataxia remained.

In 1 cat the effect of repeated administration of the drug was studied. When 75 mg. per kilogram was administered intravenously, no head drop ensued. The reflexes were diminished, and the animal was ataxic. When the injection was repeated twenty minutes later, there was a marked head drop, and the cat was mildly stuporous. It could walk when prodded but was ataxic and preferred to lie on its side. The animal showed no interest in food. The patellar and achilles reflexes disappeared. Stimulation of the external auditory canal evoked shaking of the pinna and head. Placing reactions were absent. The pupils reacted to light and nociceptive stimuli. When the same dose was repeated one hour after the first injection, the head drop was pronounced, the animal was paralyzed but respirations were not embarrassed. The animal was apparently conscious, but it did not react to pinching its foot pads or to any painful stimuli applied to its body. The cat could not right itself or walk. Patellar and achilles reflexes were absent. Stimulation of the ear evoked head shaking. Placing reactions had disappeared. The pupils reacted to light but not to nociceptive stimuli applied to the foot pad. The animal seemed to be anesthetic. Ninety minutes after the first injection the animal was still paralyzed. Respirations, however, were good. At one hundred and twenty minutes 0.1 cc. of neostigmine methylsulfate was given intramuscularly. At one hundred and sixty minutes there was no change. The animal was stuporous, paralyzed and anesthetic, but reflexes of the ear and cornea were still present. Respirations were shallow and rapid. The heart rate was rapid and regular. An intramuscular injection of 0.1 cc. of neostigmine methylsulfate was given. At one hundred and eighty minutes there was no change.

Effect on Peripheral Nerves.—The effect of lissephen® on electrical stimulation of the peripheral nerves and muscles has been described in a separate report.[3] Lissephen® caused little or no change in rheobase,

3. Finkelman, I., and Arieff, A. J.: The Action of α:β Dihydroxy-γ-(2-Methylphenoxy)-Propane (Lissephen) on Peripheral Nerves, J. New & Ment. Dis. **109**:326 (April) 1949.

chronaxia, galvanic tetanus ratio or threshold for repetitive stimuli, even after the administration of toxic doses. While these tests on nerve and muscle were made, the cat showed the general effects of lissephen.® The extremities were paretic and hypotonic, and the animal was immobile and failed to react to nociceptive stimuli, as previously described. When purified chondodendron tomentosum extract (intocostrin®), a preparation of curare, was injected, there was a definite increase in rheobase and the threshold for repetitive stimuli. With increased doses of intocostrin,® even 25 milliamperes produced no contraction of the muscle when stimulated through the nerve, although the muscle contracted when stimulated directly.

From these observations it is concluded that lissephen® does not act on the myoneural junction, as does curare. This observation is contrary to the statement of Berger and Bradley [1] that the effect of the drug on mammalian nerve-muscle preparations was similar to that of curare.

Effect on the Spinal Animal.—The experiments were performed on a cat in which the continuity of the spinal cord had been interrupted at the sixth thoracic segment three weeks previously. The lower extremities were paralyzed and were spastic in slight flexion. When the foot was pinched, there were flexion responses to nociceptive stimuli applied up to the level of the lesion. There was absence of placing reactions, and the spasticity was characterized by sudden release when the leg was further flexed at the knee and thigh. Stepping reflexes were present. There was occasional ankle clonus, and fanning of the toes was present on stimulation of the foot pad. When 60 mg. per kilogram of lissephen® was administered intravenously, the animal became restless and there was an immediate head drop. There was a definite diminution of tonus in the extremities, and the flexor response to pinching the toes diminished. Reflex responses to nociceptive stimuli applied to the trunk disappeared. The crossed extensor response was still present. The upper extremities were hypotonic. Ten minutes after the injection the head drop had disappeared. After thirteen minutes, the crossed extensor response was absent, and the flexor reflexes were markedly diminished. No steppage reflexes or clonus was elicited, and a flexor response could no longer be obtained by nociceptive stimuli to the body. Only a pinprick to the foot pad elicited a flexor response. After seventeen minutes ankle clonus returned. After nineteen minutes the flexor reflexes became more active and stronger in the extremity resting on the table. After twenty-two minutes bilateral flexor reflexes were well established again, but extensor responses were not elicited. Fanning of the toes was elicited when the

contralateral leg was flexed. There was an increase in tone in the leg resting on the table. There was only an occasional flexor or crossed extensor response to pinprick on the foot, and bilateral extensor and flexor responses were elicited on pinching the tail. After thirty minutes, fanning of the toes on stimulation of the foot pad, hypertonia and the contralateral extensor thrust returned. A clonus response then occurred in the foot in response to pinprick, and the flexor response in the legs was elicited by nociceptive stimuli from the body below the level of the lesion. There was jackknife spasticity bilaterally. This experiment was repeated on six alternate days, with the same results. The effects of lissephen® on the animal with respect to mobility and response in the upper extremities were the same as those noted in normal animals.

From observations made on this animal, it was concluded that reflex activities of the spinal animal were markedly diminished, and in some instances abolished. Whether this was due to an effect on sensory, motor or internuncial pathways could not be determined.

EFFECT ON DECEREBRATE RIGIDITY

Decerebration of the cat was carried out by the anemia method of Pollock and Davis [4] with the animal under ether anesthesia. Ten minutes after the operation, while on its back, the animal showed extensor rigidity. The rigidity in the hindlimbs was less pronounced. Extension of the head exaggerated rigidity of the forelegs. When the animal was held upright, the forelegs as well as the tail showed rigidity. Extension of the head at this time again increased the rigidity of the forelegs. When the animal was held in the air with back down, the forelegs and hindlegs relaxed, without relation to the position of the head. Twenty minutes after operation, with the animal in the standing position, the forelegs were rigid, but the hindlegs did not give sufficient support for standing. Rigidity, however, was pronounced. There were a tremor of the proximal part of the tail and switching of the distal segment. There were no flexor or contralateral extensor reflexes. Thirty minutes after operation, the animal was standing on its rigid extremities when the head was hyperextended. The tail was extended and rigid. When the head was flexed, rigidity disappeared, and the animal collapsed. Running reflexes occurred at this time when the animal was supported in the air. When the head was turned, the opposite upper extremity was flexed.

Lissephen,® 60 mg. per kilogram, was then administered intravenously forty minutes after operation. Respirations immediately

4. Pollock, L. J., and Davis, L.: The Reflex Activities of a Decerebrate Animal, J. Comp. Neurol. **50**:377 (Aug.) 1930.

became more rapid and shallow and then slow and deep. The tail, which had previously been extended and rigid, dropped, and the forelegs and hindlegs became flaccid. Respirations then became of good quality and regular. No labyrinthine or tonic neck reflexes were elicited. The patellar and achilles reflexes were absent. There was no extensor thrust on the contralateral side. Five minutes after the injection of lissephen® there were crossed stepping reflexes when the toes were pinched. In ten minutes the neck reflexes returned. There was an increase in tone. Fifteen minutes after the injection of lissephen,® the labyrinthine reflexes returned, and there was extension rigidity, more noticeable in the hindlimbs when the animal was supported in the air. In twenty minutes the tail extended. It was concluded, therefore, that reflex activities elicited from levels as high as the pons likewise disappeared, especially the labyrinthine and the neck reflexes.

EFFECT OF LISSEPHEN® ON EXCITATION OF THE MOTOR CORTEX AND CONDUCTION THROUGH THE PYRAMIDS

These studies are reported elsewhere.[5] For recording potentials an electron tube amplifying system, consisting of a preamplifier, cathode ray oscilloscope, power amplifier and loud speaker, was used. Photographs of the wave forms and base line were taken. The motor cortex of the cat was stimulated by the application of 3 per cent strychnine for one-half minute just anterior and posterior to the cruciate sulcus in its mid position. Potentials were obtained from this area and the left pyramid rostral to decussation by leading off enameled wire electrodes from these respective areas.

Strychnine spikes were observed and photographed from both the cortex and the pyramids. After the injection of lissephen,® the cortical spikes continued, but none could be observed at the pyramid. Moreover, although the cortical spikes remained, the movement of the corresponding extremity disappeared. From this it could be concluded that lissephen® did not act on cortical cells but that impulses from the pyramid were impeded. This was shown not only by the absence of potentials but also by the disappearance of the usually occurring movement of the opposite extremity, indicating that the impulses from the cortex were impeded not only in the pyramids but also in the corticospinal tract. Lissephen® in its effect of diminishing activity or producing impedance acts on subcortical efferent pathways.

5. Finkelman, I., and Dobin, N. B.: Effect of $\alpha:\beta$ Dihydroxy-γ-(2-Methylphenoxy)-Propane (Lissephen) on Excitation of the Motor Cortex and Conduction Through the Pyramids, J. New. & Ment. Dis. **109**:323 (April) 1949.

As has already been noted, lissephen® produces, in addition, some anesthesia. It was shown by Berger and Bradley [1] that the drug potentiates the effect of barbiturate narcosis and that it acts as a local anesthetic. The problem remains of evaluating how much its action on sensory elements contributes to the disappearance of spasticity and spasm. It cannot be stated from experiments up to this point how the drug exerts its effect on certain reflex activities and on the impedance of movements produced by cortical stimulation. Further to elucidate this, the following experiment was carried out. The motor cortex of a cat was explored and stimulated with faradic current, with production of a movement in the corresponding contralateral upper extremity. On the injection of 45 mg. per kilogram of lissephen,® no movement could be obtained by faradic stimulation. From this it is clear that, whatever effect lissephen® may have in producing anesthesia in large doses, one need not search beyond its effect on the motor system for its chief activity.

SUMMARY

The effect of lissephen® (3-o-toloxy-1,2-propanediol) was studied in general, as well as on peripheral nerves, the spinal animal, the decerebrate preparation, the motor cortex and the pyramids. Lissephen® in appropriate doses caused paralysis, immobility, disappearance of most of the reflexes, head drop and lowered response to sensory stimuli. In toxic doses it caused death, due to respiratory failure.

The effect of lissephen® on peripheral nerve is unlike that of curare. Electrical studies revealed little or no change in rheobase, chronaxia, galvanic tetanus ratio or repetitive stimuli ratios, even after toxic doses were administered. At times there was a slight increase in threshold for all tests, but the normal relation was present and remained so.

Lissephen® caused the disappearance of tone in a spinal animal. The flexor responses to nociceptive stimuli applied to the body were first to disappear, and later those applied locally disappeared. Then the contralateral extensor thrust, ankle clonus and fanning response of the toes disappeared. Within the course of thirty minutes, all these responses reappeared in that order, including the spasticity.

Lissephen® caused immediate disappearance of the rigidity of a decerebrate animal. All the reflexes, including labyrinthine and tonic neck reflexes, were abolished. Within twenty-five minutes the rigidity, as well as the reflexes, reappeared.

Lissephen® did not abolish strychnine spikes in the motor cortex, whereas those led off from the pyramids were suppressed. The effect of lissephen® lasts from seven to thirty minutes, the longest action being observed in a spinal animal.

It was shown by studies on peripheral nerve that the action of lissephen® does not occur at the myoneural junction. In studies on the spinal animal and decerebrate rigidity, although reflex activity and spasticity disappeared, it could not be determined whether this was the result of action on the sensory or the motor elements. However, lissephen® did not abolish strychnine cortical spikes, but the corresponding movements were suppressed. In fact, after the injection of lissephen® we could not produce movements ordinarily produced by faradic current. The effect was not the result of anesthesia but was exerted on subcortical efferent pathways.

30 North Michigan Avenue.

INTRAPEDUNCULAR HEMORRHAGE OF THE BRAIN

Successful Operative Approach, with Evacuation of Clot and a Seven and One-Fourth Year Observation Period

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A CASE is reported of recurrent hemorrhage into the left cerebral peduncle, with adjacent pressure on the cerebral aqueduct, culminating in an acute surgical emergency. An operative approach, with successful evacuation of the hemorrhagic clot from the peduncle, is described. At the time of this report, seven years and three months later, the patient was leading a normal life, with minimal residual symptoms.

Intrapeduncular hemorrhage is not uncommon. The resulting clinical syndromes have been named after Weber, Millard-Gubler, Gruber, Benedict and Parinaud. The onset is frequently sudden, and the results are serious. If the hemorrhage is large, death is immediate; if the hemorrhage is small, the adjacent edema subsides, and there is delayed incomplete recovery with permanent residual disability.[1a]

The peduncle is roughly trapezoidal, its two sides representing the two peduncles, its dorsal top the tegmentum and its ventral base the basilar portion. The aqueduct pierces the center of the tegmentum; on either side lie the nuclei of the third nerve, with their fibers running ventrally through the heart of the red nucleus. Separating the tegmentum from the basal portion are the medial and lateral lemnisci. The basal portion carries the pyramidal tracts, as well as the corticobulbar motor tracts. The medial lemniscus carries the

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From the Department of Neurosurgery, Lahey Clinic, Boston (Dr. Poppen).

The first report of this case presented at the Annual Meeting of the American College of Surgeons, Boston, September 1941.

1. Grinker, R. R.: Neurology, Springfield, Ill., Charles C Thomas, Publisher, 1945: (*a*) Neuro-Anatomy of Mid-Brain, pp. 38-39; Clinical Syndromes of Mid-Brain Lesions, p. 326.

spinothalamic sensory tracts. The red nucleus controls coordination, lesions here resulting in tremor and weakness. The vascular supply of this region is through the superior cerebellar and upper pontile branches of the basilar artery. Hemorrhage of the superior cerebellar artery [2] gives a specific syndrome of ipsilateral cerebellar ataxia, dysarthria, weakness of the seventh nerve, paralysis of the sympathetic fibers, contralateral hemiparesis, hemianesthesia and possible deafness. Weber's syndrome consists of ipsilateral palsy of the third nerve and contralateral hemiplegia, due to a lesion in the basal portion of the peduncle. Benedict's syndrome [3] consists of ipsilateral palsy of the third nerve with contralateral tremor, due to a lesion in the tegmentum, including the red nucleus. If the corpora quadrigemina are involved, conjugate gaze, especially upward, is affected (Parinaud's syndrome). Any of these lesions may cause, in addition, contralateral involvement of cranial nerves, especially the vagus, due to destruction of the corticobulbar tract. If one remembers that the entire diameter of both peduncles is not much larger than one's finger, one realizes that a clot of any size can give massive destruction of motor and sensory functions, coordination and cranial nerve functions.

REVIEW OF LITERATURE

Operative exposures of the peduncle have been few. Naffziger [4] in 1928 described a supratentorial approach for exposure of deep occipital and superior cerebellar tumors in which he elevated the occipital lobe, split the tentorium and had a limited visualization of the peduncle and the superior cerebellar surface. Fay [5] invented special tentorial clip applicators in order to facilitate the splitting of the tentorium for exposure of tumors in the region of the peduncle and the

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2. Freeman, W., and Jaffe, D.: Occlusion of the Superior Cerebellar Artery, Arch. Neurol. & Psychiat. **46**:115-126 (July) 1941. Rowbotham, G. F.: Small Aneurysm Completely Obstructing Lower End of Aqueduct of Sylvius, ibid. **40**:1241-1243 (Dec.) 1938.

3. Trelles, J. O.; Suarez, L., and Mendez, M.: Un caso anatomo-clínico de síndrome de Benedikt, Rev. neuro-psiquiat. **1**:51-84, 1938; abstracted, Arch. latino. de neurol. **1**:112-114, 1940; Institute of Living Series 8, no. 110, 1940.

4. Naffziger, H. C.: Brain Surgery, with Special Reference to Exposure of the Brain Stem and Posterior Fossa: The Principle of Intracranial Decompression and the Relief of Impactions of the Posterior Fossa, Surg., & Obst. **46**:241-248 (Feb.) 1928.

5. Manufactured by Pilling & Company, Philadelphia.

superior portion of the cerebellum. Bailey [6] advocated this approach in cases of acoustic neuroma. Horrax [7] popularized the resection of the medial portion of the parietal and occipital lobes for the exposure of the large pinealomas. Tumors lying within the brain stem or peduncle have generally been considered inoperable, but on occasion successful decompression has been effected by the splitting of the tentorium, allowing a reestablishment of cerebrospinal circulation through the blocked aqueduct.

To the best of our knowledge, evacuation of either a hemorrhage or a tumor from within the peduncle has not been attempted previously.

REPORT OF A CASE

M. K., a housewife aged 44, was referred to one of us (W. B. S.) in neurosurgical consultation by Dr. W. Townsend, of Hartford, Conn., in September 1940. The history included toxemia of pregnancy about two years prior to that time, with low grade hypertension thereafter. Approximately one and one-half years before her admission in March 1939, there was onset of numbness of the right hand, which spread to the face and legs. In July clumsiness developed in the right hand, spreading to the right foot, accompanied with occipital headaches. In March 1940 she was admitted to the Hartford Hospital, where lumbar puncture yielded spinal fluid under a pressure of 135 mm. of water with a total protein content of 34 mg. per hundred cubic centimeters and no cells. At that time, neurologic examination revealed a slight increase in deep reflexes on the right as compared with the left, with ankle clonus and absence of plantar response on the right side. There were distinct ataxia of the right arm and hand, questionable weakness of the right seventh nerve of supranuclear origin and slight subjective numbness of the fifth nerve. Laboratory tests revealed nothing significant except for an increase in the blood sedimentation rate on repeated examinations, the rate averaging 58 mm. in one hour. The patient was referred to the Lahey Clinic where an air encephalogram, an electroencephalogram and a ventriculogram all revealed a condition within normal limits. The patient was consequently discharged, with a diagnosis of multiple sclerosis.

In August 1940, bilateral weakness of the third nerve developed, without scotomas or field defects. Three weeks later the patient complained of occipital headaches of increasing severity and was readmitted to the Hartford Hospital in September 1940. She was vomiting and stuporous. When seen by one of us (W. B. S.), she exhibited flaccid hemiplegia on the right side, involving

6. Bailey, P.: Concerning the Technic of Operations for Acoustic Neurinoma, Zentralbl. f. Neurochir. **4**:1-5 (Jan.) 1939.

7. Horrax, G.: Extirpation of a Huge Pinealoma from a Patient with Pubertas Praecox: A New Operative Approach, Arch. Neurol. & Psychiat. **37**:385-397 (Feb.) 1937.

the arm and leg, with increased deep reflexes and a positive Babinski sign, bilateral weakness of the seventh nerve of supranuclear type, and loss of all conjugate movements of the eyes, with pinpoint pupils and mild ptosis of both lids. The miosis and ptosis were more conspicuous on the left. The right corneal reflex was absent. Severe cerebellar ataxia of the right hand had been noted by Dr. Townsend before the patient lapsed into coma. The spinal fluid pressure was then 235 mm. of water, with 150 erythrocytes per cubic millimeter, no leukocytes and 39 mg. of total protein per hundred cubic centimeters. Roentgenograms of the skull revealed a slight shift of the pineal gland to the right. A ventriculographic study was made on Sept. 8, 1940. The air studies revealed diffuse dilatation of the ventricular system (more on the left side than on the right). The third ventricle was poorly filled, but the posterior portion was adequately visualized.

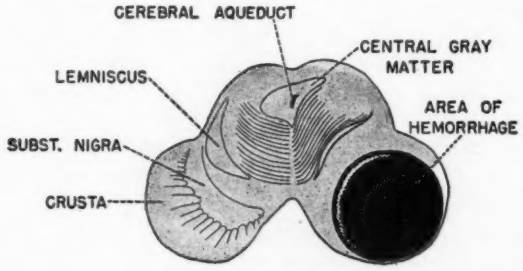
The preliminary diagnosis was that of a tumor invading the region of the left side of the midbrain adjacent to the corpora quadrigemina. Because of the magnitude of the contemplated operation, and because she had previously been studied at the Lahey Clinic, it was deemed advisable to take her once again to the Lahey Clinic. She was immediately transferred by stretcher and railroad. On her arrival we were in agreement that the patient presented a picture of a lesion of the upper part of the brain stem, either in the pons or in the peduncle, adjacent to the corpora quadrigemina. The prognosis was deemed almost hopeless. At the insistence of one of us (W. B. S.), the other (J. L. P.) consented to perform the radical procedure of a left occipital lobectomy with splitting of the tentorium and consequent full visualization of the pineal body, corpora quadrigemina, peduncle and pons.

Operation.—A medium-sized bone flap was turned down in the left parieto-occipital region. The dural flap was reflected medially to the sagittal sinus. The appearance of the brain was normal except for moderate flattening of the convolutions. With the aid of the electrosurgical unit, the occipital lobe was resected, allowing excellent exposure of the tentorium and the posterior portion of the falx. The left hemisphere was gently elevated medially, permitting a limited view of the upper portion of the cerebral peduncle. It was obviously larger than normal and had a dark blue color. The tentorium was incised to the incisura, allowing excellent exposure of the cerebellopontile angle, including the pineal gland. The cerebral peduncle was at least twice its normal caliber and was fusiform. A longitudinal incision was made posteriorly at the site of the greatest bulging. A chocolate-colored mass immediately extruded through the incision. There seemed to be a limiting membrane, and when this was incised, syrupy black blood escaped. Small portions of organized clot could readily be removed. A smooth, glistening surface could be seen as soon as the entire old clot had been thoroughly evacuated. No evidence of an aneurysm could be seen, even though its presence was suspected. The usual closure for a craniotomy was made.

Postoperative Course.—The immediate postoperative course was most gratifying. The patient returned to Hartford at the end of three weeks. At that time she was able to sit up in a chair. Her previous right hemiparesis and thick,

slurred, bulbar speech continued, but was less pronounced. Within one month after the operation, she was able to walk; her mental status was normal except for pathologic laughing and crying. She showed a residual mild spastic hemiparesis and hemianesthesia to pain and temperature (including the corneal reflex) on the right side and a pronounced cerebellar type of ataxia of the right hand only. The left pupil remained contracted. A bulbar type of thick speech and rather easy choking on fluids persisted. Permanent right homonymous hemianopsia resulted from the occipital lobectomy.

Examination one and one-half years after the operation, on May 12, 1942, revealed a 75 per cent recovery. The patient walked into the office and showed no appreciable paresis. Her gait was symmetric, although mildly unsteady and on a wide base. The reflexes were still stronger on the right than on the left, but the plantar reflexes were normal. The right hemianesthesia for pain and sensations referable to the posterior column had disappeared. She continued to show miosis and slight ptosis of the left eye, but conjugate motions were



Schematic drawing of estimated location of clot lying within the left cerebral peduncle, with secondary pressure against the corpora quadrigemina, both third nerve nuclei and the medial lemniscus and pyramidal tract on the left side.

normal. There were a definite but mild ataxia of the left arm and a faint rhythmic tremor of the right arm. The most pronounced, and apparently only, disability causing social embarrassment was a continued bulbar type of slowed, staccato, scanning speech. Finer tests revealed a tendency still to turn her eyes to the left, weakness of the left hand grip, drooping at the right side of the palate and some hoarseness. There was minimal rotary nystagamus, especially on upward gaze. Hearing tests were symmetric and normal as made with the audiometer and tuning fork. The vocal cords and the gag reflex were normal. Neurologic examinations five and six years later revealed that the clinical picture was unchanged, the patient leading a normal life and being socially disabled only by her noticeably halting thick and staccato speech.

COMMENT

This case presented a confusing clinical picture. Six months previously, after exhaustive laboratory studies, which revealed nothing

significant, a diagnosis of multiple sclerosis had been made. Actually, the patient had had an initial small hemorrhage deep within the left peduncle proper (involvement of the medial lemniscus, the red nucleus and a portion of the basilar portion), resulting in a practically stationary clinical picture for one and one-half years. This was followed by a second, larger, hemorrhage with progression of all neurologic signs and, in addition, a block of the cerebral aqueduct. The case then became one of an acute surgical emergency with a nearly fatal outcome.

Small hemorrhages in the peduncle may easily be diagnosed mistakenly as multiple sclerosis. Such a single lesion may give Charcot's triad of tremor, scanning speech and nystagmus, as well as the "disseminated" signs of ataxia, involvement of the pyramidal tract, rigidity and diplopia. This is one of the few cases of a circumscribed lesion within the midbrain in which the diagnosis could be corroborated in vivo and its specific clinical picture thoroughly studied. The lesion resulted in (1) initial progressive contralateral hemianesthesia for all sensation, including that of the face and cornea (medial lemniscus); (2) contralateral ataxia and flaccid weakness of the arm and spreading to the leg, accompanied with signs referable to the pyramidal tract (red nucleus and basilar part of the pyramidal tract); (3) loss of all conjugate ocular movements (corpora quadrigemina); (4) pinpoint pupils and mild ptosis, greater on the same side (bilateral nuclei of the third nerve); (5) bilateral weakness of the seventh nerve of supranuclear origin (Freeman and Jaffe[2]); (6) weakness of the right side of the palate, hoarseness, dysarthria and severe scanning speech (supranuclear lesion of the vagus and brachium conjunctivum); (7) delayed contralateral tremor (red nucleus), (8) initial contralateral, and later ipsilateral, ataxia of the arms (due perhaps to involvement of the brachium conjunctivum at its point of decussation).

The operative approach used by one of us (J.L.P.), undertaken as a heroic measure, resulted in improvement beyond all expectation, and the patient has held this improvement for seven and one-half years. The decompressive effect of this operation should be of benefit in cases of tumors and hemorrhages within the pons and mesencephalon, while its wide exposure should facilitate exploration of such lesions when located anterior to the midbrain.

SUMMARY

A case of a recurrent intrapeduncular hemorrhage with block of the aqueduct, resulting in an acute surgical emergency, is reported.

The resulting clinical picture, with its similarity to multiple sclerosis, is described in detail.

An operative approach to the peduncle is described.

Surgical evacuation of the peduncular hemorrhage was performed with gratifying results. At the time of this report, improvement has been maintained for approximately seven years and three months.

85 Jefferson Street, Hartford, Conn. (Dr. Scoville).
Lahey Clinic, Boston (Dr. Poppen).

THE ELECTROENCEPHALOGRAM AFTER INJURY TO THE SPINAL CORD IN MAN

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IT IS WELL established that various forms of sensory stimulation may, under certain conditions, evoke changes in the electrical potentials of the brain of the experimental animal [1] and of man.[2] It has also been demonstrated that the spontaneous electrical activity of the cortex of the anesthetized animal may be modified by reducing the afferent inflow to the cerebrum.[3]

There is little direct evidence to indicate that the normally incident afferent inflow by way of the spinal cord in man plays a role in determining the character of the cortical potentials. Kaplan [4] recently reported electroencephalographic studies in 10 cases of disease of, or involving,

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1. (*a*) Forbes, A., and Morison, B. R.: Cortical Response to Sensory Stimulation Under Deep Barbiturate Narcosis, J. Neurophysiol. **2**:112, 1939. (*b*) Lewy, F. H., and Gammon, G. D.: Influence of Sensory Systems on Spontaneous Activity of Cerebral Cortex, ibid. **3**:388, 1940. (*c*) Marshall, W. H.; Woolsey, C. N., and Bard, P.: Observations on Cortical Sensory Mechanisms of Cat and Monkey, ibid. **4**:1, 1941.

2. (*a*) Adrian, E. D., and Matthews, B. H. C.: The Berger Rhythm: Potential Changes from the Occipital Lobes in Man, Brain **57**:355, 1934. (*b*) Davis, H.; Davis, P. A.; Loomis, A. L.; Harvey, E. N., and Hobart, G.: Electrical Reactions of the Human Brain to Auditory Stimulation During Sleep, J. Neurophysiol. **2**:500, 1939. (*c*) Dawson, G. D.: Cerebral Responses to Electrical Stimulation of Peripheral Nerve in Man, J. Neurol., Neurosurg. & Psychiat. **10**:137, 1947.

3. (*a*) Bremer, F.: Cerveau "isolé" et physiologie du sommeil, Compt. rend. Soc. de biol. **118**:1235, 1935; (*b*) Effets de la déafférentation complète d'une région de l'écorce cérébrale sur son activité électrique spontanée, ibid. **127**:355, 1937. Footnote 1.

4. Kaplan, L. I.: The Electroencephalogram of Patients with Cord Lesions, read before the Eastern Association of Electroencephalographers, New York, Dec. 11, 1947.

the spinal cord and stated that in all cases there were manifest abnormalities in the records. The electroencephalograms were characterized by the occurrence of paroxysmal 5 to 7 cycle per second activity, in most cases appearing focally in the motor, and occasionally in the parietal, region. In many of these cases the possibility of a coincident cerebral pathologic process cannot be excluded.

It was felt that studies limited to patients known to have sustained traumatic lesions of the spinal cord would provide information of value. Electroencephalographic studies were undertaken on 18 patients,

Clinical Data on 18 Patients with Injuries to the Spinal Cord

Patient	Sensory Level	Laminectomy Findings	Number of Months Between Injury and Electroencephalographic Recording
1	Th 4	Complete anatomic transection	3
2	Th 3	Pronounced atrophy and cavitation of cord *	4
3	Th 8, right } Th 10, left } (partial)	Not done	5
4	Th 3	Hematomyelic cavity *	12
5	Th 12 (partial)	Not done	17
6	L 1-2 (partial)	Retained fragments of bone	27
7	Th 7	Complete necrosis of cord	32
8	C 4-5 (partial)	Slight atrophy of cord	33
9	L 5	Laceration of dura and most roots of the cauda equina	33
10	C 5	Advanced atrophy of cord *	35
11	Th 7-8	Not done	40
12	Th 5-6	Atrophy of cord	40
13	C 3-4, left (partial)	Not done	40
14	C 5	Anterior angulation of cord	41
15	Th 12	Normal appearance of cord	41
16	Th 1-3	Almost complete transection *	42
17	Th 8	Softening of cord; retained shrapnel	43
18	Th 1	Not done	44

* Absence of neural transmission through damaged area verified by direct electrical stimulation of spinal cord.

17 of whom had suffered trauma to the spinal cord with resultant partial or complete anatomic or functional transection of the cord. The other patient in this series had had spontaneous hematomyelia, which resulted in paraplegia. The location and nature of the injury were verified by exploratory laminectomy in 13 cases, and in 4 of these the failure of neural transmission through the damaged area was further verified by direct electrical stimulation of the cord. Pertinent clinical data are given in the accompanying table.

METHODS

All recordings were made with the four or eight channel Grass ink-writing oscillograph, using flat solder electrodes fixed to the scalp with collodion. A standard eight electrode placement was used, an additional pair of electrodes

being placed over the postcentral region in most cases. The usual monopolar and bipolar tracings were made, and a three minute period of hyperventilation was included in each run. Tracings were examined for unusual characteristics of frequency, amplitude or wave form.

RESULTS

In 16 of the 18 patients the records were classified as being within normal limits. The tracings of patient 10 exhibited focal, nonparoxysmal, slow activity. This patient had suffered trauma to the head coincident with the injury to the spinal cord and had a history of seizures. It was demonstrated that the electroencephalographic focus corresponded with an area of presumed cortical atrophy, as evidenced by ventricular air studies. The record of patient 17 contained 6 to 7 cycle per second activity of moderate relative amplitude, appearing in short runs in all leads, of the type reported by Gibbs, Gibbs and Lennox [5] in 7.6 per cent

COMMENT

The data in this study do not support the thesis that chronic lesions of the spinal cord in man, by altering the afferent inflow to the brain, produce manifest electroencephalographic abnormality. The possibility that special technics or special analysis of the tracings might disclose some electroencephalographic abnormality is not excluded.

In animal experiments the demonstration of the effect of reduction of the afferent inflow has been accomplished, in the main, by sections through the upper portion of the brain stem [6] or by isolation of a portion of the cerebral cortex.[3b] Lewy and Gammon [1b] reported that, in the cat under pentobarbital® anesthesia, "successive transections from below upward through the spinal cord, medulla, and pons cause a progressive diminution in size of the cortical discharges, but their grouped character remains unchanged." Our data provide no information on such a decrease in amplitude of the electroencephalograms after transection of the cord in man, since no electroencephalograms were made prior to trauma.

The shortest interval between injury to the cord and electroencephalographic recording in this series was three months, and in most cases it was considerably longer (table). The influence on the electroencephalogram of man of the sudden withdrawl of afferent impulses cannot therefore be evaluated from these data. Studies bearing on this aspect are now in progress.

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5. Gibbs, F. A.; Gibbs, E. L., and Lennox, W. G.: Electroencephalographic Classification of Epileptic Patients and Control Subjects, Arch. Neurol. & Psychiat. **50**:111-128 (Aug.) 1943.

6. Lewy and Gammon.[1b] Bremer.[3a]

SUMMARY AND CONCLUSIONS

1. The electroencephalograms of 18 patients with partial or complete transections of the spinal cord were studied. The interval between injury to the spinal cord and electroencephalographic examination varied from three to forty-four months.

2. The data do not indicate that injuries to the spinal cord which alter the afferent inflow to the brain in man produce abnormalities in the electroencephalogram.

National Veterans Epilepsy Center.

Case Reports

PSYCHOSIS WITH HEMATOPORPHYRINURIA

Clinical Report of a Case

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HEMATOPORPHYRINURIA is a rare disease, probably familial in origin, and caused by an inborn error of the hemoglobin metabolism, in the form of a reversion to an embryonic type.[1] From the etiologic point of view the porphyrias have been classified as congenital, acute and chronic. The acute form has been further subdivided into acute toxic and acute idiopathic porphyria.[2] As pointed out by Watson and others,[3] the acute toxic and the acute idiopathic form probably represent the same condition and are indistinguishable either clinically or by laboratory procedures. It is assumed that both forms are produced by some toxic agent, which in the acute idiopathic form has not been identified, while in the acute toxic form it is usually a barbiturate or one of the members of the sulfonamide group.[4] However, Eldahl [5] stressed the fact that conditions such as anxiety, exhaustion and infection can also act as precipitating factors in the acute toxic form. It has been mentioned that both the acute toxic and the acute iodiopathic form are commoner in women than in men and that in women they are often associated with menstrual disorders.[6] The condition may be familial and then is inherited as a dominant mendelian character.

Clinically, all types have the following symptoms in common: (1) the color of the urine, (2) pigmentation of the teeth and bones and (3) sensitivity of the skin to light. In addition, various types of gastrointestinal disturbances, such as nausea, vomiting, constipation,

From the Eastern State Hospital.

1. Günther, H.: Die Hematoporphyrie, Deutsches Arch. f. klin. Med. **105**: 89-146, 1911.

2. (*a*) Duncan, G. G.: Diseases of Metabolism, Philadelphia, W. B. Saunders Company, 1943. (*b*) Nesbitt, S., and Watkins, C. H.: Acute Porphyria, Am. J. M. Sc. **203**:74-83, 1942.

3. Watson, C. J.: The Porphyrins and Their Relation to Disease: Porphyria, in Christian, H. A., and MacKenzie, Oxford Medicine, New York, Oxford University Press, 1938, vol. 6, pp. 1-34. Mason, V. R.; Courville, C., and Ziskind, E.: Porphyrins in Human Disease, Medicine **12**:355-439, 1933.

4. Fetter, F.; Humphrey, A. A., and Longenecker, C. R.: Acute Idiopathic Porphyria, U. S. Nav. M. Bull. **43**:349-352, 1944.

5. Eldahl, A.: Case of Acute Porphyria Developed During Hospitalization, Acta med. Scandinav. **97**:415-419, 1938.

6. (*a*) Günther.[1] (*b*) Geissler, J.: Zur Kenntnis der Porphyria acuta, Klin. Wchnschr. **18**:378-380, 1939.

abdominal pain and even jaundice have been observed. Furthermore, in the acute toxic and acute idiopathic forms there have been noted symptoms of various abnormalities of the central nervous system, such as paralyses (usually of the ascending, Landry type), psychotic manifestations and occasionally symptoms of renal impairment. If symptoms referable to the central nervous system or psychic disturbances are present, the mortality rate is about 75 per cent.

It is of great importance to recognize this condition,[7] for failure to do so, according to Geissler,[6b] has "often led mistakenly to surgical intervention because a diagnosis of intestinal obstruction, peptic ulcer, gallstones, renal calculus or appendicitis was made. The absence of organic changes has led to the assumption of hysteria or malingering." Pathognomonic of this disorder is the spectroscopic demonstration of uroporphyrin in the urine. Another diagnostic test of value is the exposure of the urine to filtered ultraviolet rays. A pink fluorescence develops if porphyrins are present.[2a]

No effective treatment is known. Development of the congenital type, however, can be warded off by avoidance of exposure to extreme sunlight and protection of the cutaneous lesions from secondary infection; improvement in the acute toxic and the chronic type can be produced by elimination of the offending agent.

The literature contains about 300 case reports of porphyrias of all types. These reports, however, are concerned mainly with the physical findings, and the diagnosis was made on the basis of the physical signs. Although in many cases nervous and psychic symptoms have been stressed as secondary manifestations, no report has yet appeared in which the psychic manifestations were of primary importance. For this reason the following case is reported. In this case the psychotic manifestations presented the major symptoms for which the patient was committed to a state hospital, while the physical findings were of only secondary importance.

REPORT OF A CASE

The patient, an American-born housewife aged 41, was committed to Eastern State Hospital because of a mental disturbance characterized by hyperactivity, restlessness, delusions, hallucinations and ideas of persecution. The attack started about three weeks prior to the patient's commitment. At that time she had a miscarriage. She became "nervous," expressed paranoid ideas, claiming that her food was poisoned, and experienced hallucinations of hearing and smell. She heard voices and talked to them, and continuously thought she was smelling cyanide gas in her room. On one occasion she tried to drink lysol® (saponated solution of cresol U. S. P.) in order to cure an imaginary infection. She also believed that her family was trying to poison her and thought she was being "doped." She became extremely talkative, but her stream of thought was incoherent and irrelevant. She displayed many peculiar and bizarre mannerisms. She also expressed ideas of grandeur and, in addition, demanded much attention. She seemed self centered and minimized her illness. All this started while she was confined to a general hospital for the miscarriage. The husband was called to the hospital by the nurses, who told him that they were unable to take care of his wife because of her extremely peculiar and hyperactive behavior. She refused to take medicine,

7. Levy, S., and Klein, R. J.: Hematoporphyrinuria: Review of Literature and Report of a Case of Chronic Type, Ann. Int. Med. **25**:520-525, 1946.

water or even food because she thought everything was poisoned. She became irritable, and even combative, when not given her own way. She thought that people were plotting against her and that someone was shooting at her. She also expressed ideas that somebody had stabbed her husband in the back. She became extremely agitated and expressed many somatic delusions.

Medical History.—About eight years ago the patient had had a similar psychotic attack. At that time she was committed to a state hospital, where she remained about six weeks. The mental diagnosis at that time was "post-infectious psychosis." This attack came on shortly after an illness with influenza. At that time she apparently was given a large amount of sulfonamide drugs, and one night, while she was in the general hospital, she suddenly experienced auditory hallucinations, showed disturbances of mood and seemed irrational. During this time she thought she was dead or dying. She heard her physician's voice at night saying that she would die, and on at least one occasion she thought the doctor and another man were standing outside her window and were exerting some influence on her to cause her death. To protect herself from this, she shielded her heart with a handful of Unity literature and moved it about various parts of her body, which she thought were being injured by this influence. After this, she had many ideas of sin, became extremely hyperactive and restless and was unable to concentrate for even the shortest period of time. While she was at the state hospital, her psychotic episode cleared up rather suddenly. She seemed to acquire insight into her condition but continued to express many psychoneurotic complaints. After a very short stay at the state hospital, she was released as recovered.

Personal History.—The patient's birth and development had been entirely normal. She walked and talked at the normal time, and toilet habits were established at the average age. She had had the usual childhood diseases, without complications, and had had a tonsillectomy at the age of 32. There was a history of sinus inflammation and colds, for which she always took huge quantities of acetylsalicylic acid. There was also a history of gastric disturbances, but she seemed to get relief from these attacks by taking alka seltzer.® In addition, she had had occasional abdominal symptoms, such as diarrhea, nausea and vomiting, and the color of her skin at times was described as subicteric. The menarche was established at the average age, but the patient had always suffered from rather severe dysmenorrhea. There was a history of several abortions and miscarriages, and only one of her pregnancies terminated in a normal delivery. The patient had always been considered a rather sensitive, emotional and affectionate person. However, she exhibited psychoneurotic trends and showed a tendency to exaggerate trivialities. She seemed overly conscientious and attempted to do things perfectly. She was exceedingly industrious but at times rather reserved and given to occasional daydreaming.

There was a history of prolonged and excessive use of one of the members of the sulfonamide group and alkali, as well as acetylsalicylic acid, during the preceding few years. However, at no time had there been any outward dermal photosensitivity, although mild discoloration of the skin in the form of subicteric tint had been reported. Occasionally there had been frequency of micturition, dysuria and nocturia, but never had any discoloration of urine been reported.

Family History.—The family history was apparently essentially normal. However, it was said that the patient's father had been in rather poor health shortly before his death, his trouble having been attributed to "kidney and heart trouble."

Physical Examination.—At the present admission the patient appeared underdeveloped and somewhat undernourished, with an asthenic body build. There was evidence of dehydration, and she was extremely restless and fidgety. The

skin was somewhat subicteric, and the mucous membranes were pale. No enlarged lymph nodes were palpable, and the thyroid gland appeared normal. The heart and lungs were normal. The abdominal organs, including the liver and spleen, were normal. Neurologic examination showed an essentially normal status. The blood pressure was 150 mm. of mercury systolic and 100 mm. diastolic.

Mental Examination.—On admission the patient was extremely hyperactive, restless and agitated. She was resistive and combative. There was evidence of negativism, and she was markedly delusional and hallucinated. She refused to eat because she claimed that her food was poisoned. She also stated that she saw people outside her room who tried to kill her. She answered imaginary voices and claimed that her family physician was standing on a table in her room. She was extremely talkative, but her stream of thought was incoherent and irrelevant. The sensorium was extremely scattered, and she was not able to concentrate or to recall digits. Memory seemed impaired. She was completely lacking in insight and judgment and seemed confused and disoriented in all three spheres.

Psychologic Examination.—On the Wechsler-Bellevue intelligence scale, the patient scored an intelligence quotient of 96, which placed her in the average adult group. The Minnesota Multiphasic Personality Inventory revealed no pathologic traits, although it brought out some hysteria, together with psychasthenia, and there was a high paranoia score, which, according to the examiner, suggested that the aforenamed characteristics might also include delusions of persecution and oversensitivity. All these psychologic tests were given at a time when the patient was clinically free of psychotic symptoms.

Laboratory Examinations.—The color of the urine varied from amber to pinkish amber and reddish amber, with the specific gravity ranging from 1.017 to 1.021. At times it was dark red. The sediment contained granular casts, bacteria and a few pus cells. The reaction was always acid. Tests for albumin and sugar gave negative results in all specimens. The red blood cell count was 4,980,000, with 13.3 Gm. hemoglobin, or 83 per cent by the Sahli method. The white cell count was 9,600, with a normal differential count. Examination of the blood smear showed nothing of significance. The Wassermann and Kahn tests of both the blood and the spinal fluid gave negative reactions. The sedimentation rate was 20 mm. in one hour (Westergren method). Blood culture and a culture of the urine yielded no growth, and examination of the sputum revealed no tubercle bacilli. The fragility test of the red blood cells gave values within the normal range. The coagulation time was four minutes; the bleeding time, two minutes, and the clot retraction time, eighteen hours. The fasting blood sugar was 99 mg. and the urea nitrogen 14 mg., per hundred cubic centimeters. The icteric index was 4, and the van den Bergh test revealed less than 0.25 mg. of bilirubin per hundred cubic centimeters. Examination of stool revealed no occult blood. A roentgenogram of the chest showed nothing abnormal and the basal metabolic rate, determined on two occasions, was plus 12 and plus 18 per cent.

The port-wine color of the urine deepened on exposure to light, and the characteristic fluorescence of porphyrinuria was observed when the urine was placed under ultraviolet rays, and was even noticeable when a test tube of urine was viewed in direct sunlight. Spectroscopic examination of the urine was made at the department of chemistry and chemical engineering of the University of Washington, Seattle. The report follows:

	Absorption Bands, Angstrom Units		
"Specimen of urine after acidification	595	575 (faint)	550
Acid hematoporphyrin	596		552
Acid uroporphyrin	597	577	554

In addition, the specimen under ultraviolet light showed a strong pink fluorescence, characteristic of the porphyrins. The conclusion thus seems warranted that the specimen contained both hematoporphyrin and uroporphyrin, the hematoporphyrin probably being present in the greater quantity."

Clinical Course.—The course of her illness during hospitalization was chacterized by several episodes of severe psychic disturbance, during which she had hallucinations and delusions. During these episodes it was observed that the patient's urine became darker (port-wine color) and that these changes in the color were noticeable even a few days prior to the onset of the psychotic episode. During these episodes she also complained of abdominal symptoms, such as pain, nausea, vomiting and diarrhea, and it was observed that her skin became subicteric and at times there was even evidence of a frank clinical icterus. Shock treatment consisting of both electric and metrazol® convulsive shock, was instituted in order to overcome these acute psychotic episodes. However, the shock treatment had only slight, temporary effect on her condition, and it was noted that as soon as the color of the urine returned to normal her psychotic episodes began to subside spontaneously. These attacks recurred at regular intervals at a rate of one about every three or four weeks. Treatment in this case consisted of only general supportive measures and either electric or metrazol® shock treatments. She was also given both the vitamin B complex and ascorbic acid in large doses intramuscularly and by mouth.

COMMENT

The diagnosis in this case of hematoporphyrinuria was definitely established and confirmed by the spectroscopic examination of the urine. It is of special interest that in this case the symptoms presented were primarily mental, whereas the physical symptoms were of only secondary importance. So far as we have been able to ascertain, no case of hematoporphyrinuria has yet appeared in the literature in which the mental symptoms were of primary importance and dominated the clinical picture. In fact, the patient's mental condition was such that she had twice been committed to a state hospital. During her first institutional stay her condition was diagnosed as "postinfectious psychosis," and during her present stay a provisional diagnosis of "schizophrenia, catatonic excitement" was made. Only when it was found that the patient had attacks during which she voided dark red urine, and that these episodes coincided with an exaggeration of her mental symptoms, was the diagnosis of hematoporphyrinuria considered, and subsequently confirmed by spectroscopic examination of the urine. Although a sulfonamide drug seemed to have been the offending toxic agent in the patient's first attack, it was impossible to identify the offending toxic agent in the present attack, and thus it may be assumed that her present illness was of the idiopathic type, especially since all the cardinal symptoms of this type were observed in the patient during her present attack. These symptoms include the voiding of dark red urine, psychotic manifestations, abdominal symptoms and jaundice. However, there was no history of pigmentation of the skin or of dermal photosensitivity. There was also no definite evidence that the patient's condition might be familial, but it was, as Geissler [6b] mentioned, associated with menstrual disorders. The results of the various laboratory examinations, except the spectroscopic examination of the urine, were within normal limits, and there was no evidence of any other organic disease. It is note-

worthy that the voiding of dark red urine each time antedated the acute psychotic episode by a few days, and that as soon as the attacks disappeared the patient's mental symptoms also subsided spontaneously. Various types of shock treatment had been ineffective against the underlying primary pathologic process.

SUMMARY AND CONCLUSION

A case of acute idiopathic hematoporphyrinuria is described in which the diagnosis was confirmed by uroporphyrin in the urine and by spectroscopic examination.

The clinical picture in this case was characterized by psychotic episodes, which were antedated a few days by attacks of voiding dark red urine (port-wine color) and various types of gastrointestinal disturbances, jaundice and menstrual disturbances.

The treatment in this case consisted of supportive and symptomatic measures including various types of convulsive shock treatment and administration of large doses of vitamin B complex and ascorbic acid, all of which seemed to be ineffective in the treatment of this condition.

This case is of especial interest, since the mental symptoms dominated the clinical picture.

Eastern State Hospital.

News and Comment

EXAMINATIONS FOR SCHOOL PSYCHOLOGISTS, BOARD OF EDUCATION OF NEW YORK

The Board of Examiners of the Board of Education of New York will conduct examinations in the fall of 1949 for the positions of school psychologist and supervisor of school psychologists. The salary ranges for these positions are $3,516 to $5,664 and $6,000, respectively.

Correspondence should be addressed to the Board of Examiners, 110 Livingston Street, Brooklyn 2.

THE AMERICAN BOARD OF PSYCHIATRY AND NEUROLOGY, INC.

The American Board of Psychiatry and Neurology, Inc., announces a special examination to be held on October 24 and 25 in Chicago. This examination is in addition to the regular semiannual examinations, held in May and December. Applications for this examination must be in the secretary's office no later than July 15, 1949. All requests for reexamination should be in the secretary's hands no later than the same date.

SEVENTH, EIGHTH AND NINTH NATIONAL CONFERENCES (1949) OF THE PSYCHODRAMATIC INSTITUTE

Independence Workshop: July 2, 3 and 4.

Labor Workshop: September 3, 4 and 5.

Thanksgiving Workshop: November 26 and 27. The activities consist of Psychodrama, Hypnodrama, Sociometry, Sociodrama, Group Psychotherapy and presentation of Therapeutic Films.

For further information write Psychodramatic Institute, P. O. Box 311, Beacon, N. Y.

NORFOLK MENTAL HYGIENE CENTER

The Norfolk Mental Hygiene Center, 300 West Freemason Street, Norfolk, Va., will have a vacancy in the post of director as of Aug. 1, 1949, and is considering applicants for this position. They are also looking for a well trained psychiatric social worker.

AMERICAN NEUROLOGICAL ASSOCIATION

The annual meeting of the American Neurological Association was held in Atlantic City, N. J., on June 13, 14 and 15, with headquarters at Chalfonte-Haddon Hall.

MICHAEL REESE HOSPITAL POSTGRADUATE SCHOOL SEMINAR ON RORSCHACH TEST

Michael Reese Hospital Postgraduate School offered a seminar on "Affective Reaction Patterns in the Rorschach Test," June 6 through June 10. The inquiry

centered on findings in schizophrenia, reactive depressions and milder neurotic disturbances. The seminar scrutinized the test's indications as to structure of the affects in these clinical groups and the whole personality's reaction to emotional impacts. Interpretation, rather than technic, received the main emphasis in the instruction.

The seminar was conducted by Dr. S. J. Beck, director of the psychology laboratory, of the division of neuropsychiatry, Michael Reese Hospital.

Obituaries

LEON HASTINGS CORNWALL, M.D.

1887-1949

After a long illness, Dr. Leon H. Cornwall died on March 4, 1949. He had been an ardent worker in neurology through all of his medical years.

Dr. Cornwall was born in Alexandria Bay, N. Y., on June 27, 1887. He was graduated from Syracuse University with the degree of Bachelor of Philosophy in 1907 and of Doctor of Medicine in 1910. He then came to New York and served an internship at the New York City Hospital. He remained in the hospital as assistant pathologist from 1912 to 1919; as neuropathologist from 1919 to 1923, and as director of the pathological laboratory from 1923 to 1925. From 1914 on he was attached to the Vanderbilt Clinic, College of Physicians and Surgeons, where he interested himself in neurosyphilis, taking charge of that department until illness forced his retirement.

When the Neurological Institute moved to the Medical Center, in 1929, Dr. Cornwall was appointed to the staff, first as attending neurologist, then as senior attending neurologist and in 1937 as chief of the neurosyphilitic services. During this time he taught neurology and neuropathology at the Columbia University College of Physicians and Surgeons, attaining the rank of associate professor of neurology in 1930. Neuropathology and neurosyphilis ever occupied his major interests, and in those subjects he served as consultant in a number of hospitals around New York.

In 1916, as a member of the New York State National Guard he saw service on the Mexican border, and from 1917 to 1919 he served in the United States Army in France and Germany. There much of his work was done in Army laboratories.

Dr. Cornwall was a member of the American Neurological Association, the American Neuropathological Association, the American Association of Immunology, the American Association of Clinical Pathology, the New York Academy of Medicine (secretary, Section on Neurology and Psychiatry, 1934; chairman, 1935); the New York Neurological Society (president, 1940-1941); the New York Pathological Society and the New York Society for Clinical Psychiatry.

He married Miss Elizabeth Bowe, and they had three daughters and one son, all of whom survive.

Leon Cornwall was a gentle soul. In all the long time the writer knew him he never heard him say an unkind thing of any one. His latter years were not happy ones on account of illness, but the gentle patience with which he bore his troubles endeared him to all who came in contact with him.

Abstracts from Current Literature

EDITED BY DR. BERNARD J. ALPERS

Physiology and Biochemistry

BIOCHEMISTRY OF THE SPHINGOLIPIDES: I. PREPARATION OF SPHINGOLIPIDES FROM BEEF BRAIN AND SPINAL CORD. H. E. CARTER, W. J. HAINES, W. E. LEDYARD and W. P. NORRIS, J. Biol. Chem. **169**:77, 1947.

A study was made of the various procedures reported for the isolation of cerebroside and sphingomyelin from nerve tissue. By the procedure finally adopted, 100 pounds (45.4 Kg.) of fresh beef brain yielded 1,300 to 1,600 Gm. of a crude sphingomyelin-cerebroside mixture, and 100 pounds of beef spinal cord gave 2,200 to 2,500 Gm. The latter material is more satisfactory for the preparation of sphingosine. Analyses for cerebroside and sphingomyelin are reported for the lipid fractions from 100 pounds of spinal cord. It is proposed to designate the lipids derived from sphingosine as sphingolipids.

PAGE, Cleveland.

SOLUBILITY OF NITROUS OXIDE IN BLOOD AND BRAIN. S. S. KETY, M. H. HARMEL, H. T. BROOMELL and C. B. RHODE, J. Biol. Chem. **173**:487, 1948.

Technics are described for determination of the solubility of gases in brain in vitro and in vivo. The Bunsen coefficient expressed as cubic centimeters of nitrous oxide (converted to standard temperature and pressure) dissolved by 1 Gm. of brain when equilibrated at a nitrous oxide tension of 760 mm. and 37 C. equals 0.437 ± 0.008 and 0.437 ± 0.005 for the mixed brain of dog and man, respectively. The brain-blood partition coefficient for nitrous oxide at 37 C., expressed as the solubility per gram of brain divided by the solubility per cubic centimeter of blood, was found to be 1.03 and 1.06 for dog and man in vitro, respectively, and 0.98 for the dog in vivo. After approximately ten minutes of inhalation of a constant tension of nitrous oxide, there was complete equilibrium in the dog between brain and cerebral venous blood with respect to nitrous oxide tension. The pertinence of these determinations to a method for measurement of cerebral blood flow in man and to the lipid theory of anesthesia is discussed.

PAGE, Cleveland.

INHIBITION OF COUPLED PHOSPHORYLATION IN BRAIN HOMOGENATES BY FERROUS SULFATE. E. RACKER and I. KRIMSKY, J. Biol. Chem. **173**:519, 1948.

The inhibiting effect of ferrous sulfate on brain glycolysis has been localized to the coupled phosphorylation catalyzed by the phosphoglyceraldehyde-oxidizing enzyme. Partial inhibition of this enzyme leads to inhibition of the synthesis of adenosine triphosphate which is necessary for the formation of fructose-1,6-diphosphate from glucose. The phosphoglyceraldehyde-oxidizing enzyme, prepared from yeast or muscle, restores the glycolytic activity to a brain homogenate which has been inactivated by ferrous sulfate or by the addition of proteolytic enzymes. The inactivating factor loses its activity after dialysis against 0.1 molar solution of potassium cyanide for five days. Full reactivation can be accomplished by the addition of ferrous sulfate and cysteine. The interpretation of the effect of inhibitors on complex reactions involving several enzymes is discussed.

PAGE, Cleveland.

LECITHIN, CEPHALIN; AND SPHINGOMYELIN CONTENT OF SERUM: I. AS INDICATED BY CHOLINE-PHOSPHORUS AND NITROGEN-PHOSPHORUS RATIOS. R. G. SINCLAIR, J. Biol. Chem. **174**:343, 1948.

The acetone-insoluble lipids from fairly large volumes of human, beef, dog, pig and turkey serums and from 4 samples of human plasma were isolated and analyzed for nitrogen, phosphorus and choline. They were then dialyzed to remove nonlipid impurities, reprecipitated with acetone and again analyzed. The choline: phosphorus ratios for the purified acetone-insoluble lipids indicate that cephalin makes up about 20 per cent of the phospholipids in turkey serum and about 3 to 8 per cent of the phospholipids in human plasma and in the serum of beef, dog and pig. The nitrogen: phosphorus ratios for the purified phospholipids indicate that sphingomyelin makes up 15 to 32 per cent of the total (the value of 39 per cent obtained from pooled human serums which had been stored for some time being discounted). The crude acetone-insoluble lipids were found to contain 21 to 40 per cent of diffusible, nonlipid impurities which were rich in nitrogen and apparently included some choline in all cases. PAGE, Cleveland.

CARBONIC ANHYDRASE IN THE CENTRAL NERVOUS SYSTEM OF THE DEVELOPING FETUS. W. ASHBY and E. BUTLER, J. Biol. Chem. **175**:425, 1948.

Well defined patterns of quantitative distribution of carbonic anhydrase have been reported in the central nervous system of man and of animals. Two reports have been made on deviations from the normal pattern of distribution in man incident to mental disease. As part of an effort to elucidate the significance of this enzyme in the central nervous system, a study of its fetal distribution was undertaken. In the normal fetal calf, the following observations were made: (1) a progressive caudal to rostral increase in the enzyme, approaching the adult pattern; (2) absence of the enzyme from the cerebrum until late in fetal development, in contrast to other enzymes studied in the fetal central nervous system; (3) from the seventh month to birth, except for its absence in the pallium, a repetition of the pattern of relative content of the enzyme, with an approach in magnitude to the level found in the adult. An early appearance of the enzyme was found in the blood of the fetal calf, in contrast to the finding of Meldrum and Roughton for fetal goats. In the premature and the full term human infant the data indicate (1) a caudal to rostral increase in the enzyme with increase in age; (2) a less complete approach to the adult pattern of distribution in the full term infant than in the six month calf fetus; (3) no carbonic anhydrase in the cerebrum at birth. The possibility that the absence of carbonic anhydrase from the cerebrum of the full term human infant studied may have been abnormal is considered. PAGE, Cleveland.

THE SERUM CHOLESTEROL LEVEL OF THE PREMATURELY BORN INFANT AND ITS MOTHER. M. JAMES WHITELAW, J. Clin. Investigation **27**:260 (March) 1948.

In view of recent evidence that cholesterol may be vital in steroid metabolism, Whitelaw studied the cholesterol content of the serum of premature infants and their mothers in 9 cases. Since most of the patients entered the hospital in active labor, it was impossible to control the length of time between the last meal and delivery. All newborn infants in the study weighed under 2,500 Gm. As soon as delivery was effected, the cord was clamped and cut. Fifteen cubic centimeters of blood was collected from the placental end of the cord, and an equal amount of blood was drawn simultaneously from the mother.

The method used for determination of free and esterified cholesterol was that of Schoenheimer and Sperry, as modified by Sperry.

The total cholesterol of the premature infants was determined at a mean value of 71 mg. per hundred cubic centimeters, whereas the mother's mean value was 235 mg. per hundred cubic centimeters. The free and ester fractions of cholesterol were found to be approximately 30 and 70 per cent, respectively, in both the fetal and the maternal serum. The serum cholesterol values for the immature infant were the same as those for the full term infant. The absolute levels and the partition of serum cholesterol did not vary with the degree of prematurity. The cholesterol levels of mother and infant bore no relation to each other. The author suggests that the low cholesterol value obtained for the serum of the prematurely born infant and the full term newborn infant may be due to the depressant action of estrogens.

DONALD, Philadelphia.

CARDIOVASCULAR REACTIONS TO EMOTIONAL STIMULI: EFFECT ON THE CARDIAC OUTPUT, ARTERIOVENOUS OXYGEN DIFFERENCE, ARTERIAL PRESSURE, AND PERIPHERAL RESISTANCE. JOHN B. HICKAM, WALTER H. GARGILL and ABNER GOLDEN, J. Clin. Investigation **27**:290 (March) 1948.

In an effort to offer objective criteria that emotional disturbances have an effect on cardiovascular function, the authors applied their methods to two groups of subjects. The first consisted of 23 unselected, healthy medical students in whom the emotional state termed "anxiety" existed because of the imminence of an important academic oral examination. The second group, of 12 subjects, were hospital and clinic patients with "anxiety" induced by a statement that a proposed procedure involved risk. The second group of subjects comprised 3 with congestive failure, 2 with hypertension, 3 with varied forms of syphilis and 4 with various disorders.

In the first group, cardiac output was measured on the Nickerson ballistocardiograph. Blood pressure, determined by the auscultatory method, and the pulse rate were measured at the same time. The mean pressure was estimated by adding one third of the pulse pressure to the diastolic pressure. The first determinations were made immediately before the examination of each student and again twenty-four hours after the examination. On the second group of subjects cardiac outputs were determined by the Fick method after intracardiac catheterization. Direct brachial arterial, intracardiac and pulmonary arterial pressures were recorded by means of a Hamilton manometer, and mean pressures were determined by planimetric integration. In all cases the peripheral resistance was expressed as the ratio of mean arterial pressure, in millimeters of mercury, to the cardiac index.

In the majority of persons "anxiety" had an effect on the circulation similar to that produced by small doses of epinephrine. The cardiac output, heart rate and oxygen consumption were increased. There was a moderate elevation of blood pressure, but the peripheral resistance was decreased. Cardiac output was abnormally high, in proportion to the rate of oxygen consumption. When persons with this reaction undertook muscular exercise, the normal relation between cardiac output and rate of oxygen consumption was reestablished. In certain subjects "anxiety" was decreased, but the compensatory increase in cardiac output failed to occur, with a resultant fall of blood pressure to low levels. In a small group of subjects "anxiety" resulted in an increase in peripheral resistance and an elevation of blood pressure, with no change or a fall in cardiac output.

DONALD, Philadelphia.

THE SOMATIC RECEIVING IN THE BRAIN OF THE SHETLAND PONY. E. D. ADRIAN, Brain **69**:1, 1946.

Previously Adrian reported the study of the somatic receiving area of the brain of a Shetland pony. He adds in the present paper observations on 2 more Shetland ponies, in which he used sound amplifiers to study the electrical activity of the cortex and roving electrodes over the cerebral cortex to locate the somatic cortical regions activated by light touch. The results of these studies for both ponies were in good agreement, and also in agreement with the author's previously reported study (*Brain* **66**:89, 1943). The somatic receiving area consists of an anterior part, where the contralateral nostril is represented in considerable detail, and a posterolateral part, for the contralateral half of the body and for the foreleg and hindleg. The area for the nostril equals in size that for the body and limbs. Of the area for the body and limbs, the limbs supply the lateral and the head, neck and trunk the mesial parts. Since the body surface is projected on a small area, there is a great convergence of afferent pathways. Pressure receptors as much as 17 cm. apart on the body surface have produced discharges in the same afferent unit of the cortex, and tactile receptors 40 cm. apart led to identical points. Comparison of the ratio of sensory surface to cortical receiving area suggests that the tactile discrimination of the pony's nostril is comparable to that of the human hand, and not much inferior to that of the pig's snout. No discharges to the cortex were obtained from the lips. The arrangement in the pony brain contrasts with that of the brains of the goat and sheep, where the main afferent supply to the cortex is from the lips on the same side.

FORSTER, Philadelphia.

Diseases of the Meninges

CLINICAL SIGNS OF MENINGEAL IRRITATION. JOHN E. A. O'CONNELL, Brain **69**:9, 1946.

O'Connell describes the clinical signs of meningitis and reviews the accepted opinions regarding the mechanisms responsible for them. The signs include cervical rigidity, retraction of the head, Kernig's sign, the Brudzinski neck sign, the Brudzinski leg sign and opisthotonos. O'Connell points out that the clinical signs are well accepted, but that there is no agreement as to the factors responsible for them and no causative mechanism which has been found common to all the signs.

He points out that in the development of the neuraxis and of the vertebral column a state of mild longitudinal tension persists in the intraspinal structures, since the spinal cord is not as long as the vertebral column. In observations on cadavers following extensive laminectomies, the author found that movement of the head produced measurable displacement in the longitudinal axis of the intraspinal contents. The displacement varied from 1 to 5 mm. Movement of the legs likewise produced displacement in the longitudinal axis. In meningitis the nerve roots are also inflamed. The clinical signs of meningitis are therefore thought to depend on the transmission of tension to inflamed and hypersensitive nerve roots. It is considered that the signs are postures to minimize tension, muscle spasms to limit movement productive of tension or movements designed to produce relaxation in nerve roots.

FORSTER, Philadelphia.

DISORDERS OF THE NERVOUS SYSTEM DUE TO MALNUTRITION. H. S. STANNUS, Brit. M. J. **1**:342 (Feb. 21) 1948.

Stannus noted that in disorders of the nervous system due to malnutrition there may be a disturbance in every sensory function of the body without involve-

ment of the motor function and that the symptoms are homologous, intermittent and variable. The character of the symptoms seems to suggest a widespread disturbance of function in the cortex, both cerebral and cerebellar, and probably in subcortical nuclei. Since the onset is variable and intermittent, the disorder can be explained only by a disturbance of metabolism or of the vascular system or of both. Stannus presents evidence to support the view that these disorders are due to failure in the metabolism of glucose in the neuropile of those areas of the central nervous system which have a high metabolic rate, caused, in turn, by hypoxia induced by hyporiboflavinosis and/or a deficiency of other closely associated members of the vitamin riboflavin complex.

ECHOLS, New Orleans.

THE PREMOTOR SUPPRESSOR STRIP IN MAN. M. HECAEN, M. DAVID and J. TALAIRACH, Rev. neurol. **79**:726 (Dec.) 1947.

After a review of work concerning the suppressor strip in animals and in man (Garol and Bucy), the authors report a case of observation on suppressor strip activity in man during operation for hemiparkinsonian tremor. They confirm the findings of Garol and Bucy and Niemeyer but state the belief that the suppressor strip lies farther posteriorly and closer to area 4. They describe the finding of separate points which exhibit different suppressor effects. At one point they found on stimulation total collapse of tonus with cessation of tremor; at another, total cessation of tremor without change of tonus, and at another, slight cessation of tremor. The various sites were not joined by areas in which intermediate effects were obtainable. The authors state the belief that in operations for hemiparkinsonism the strip area should be preserved.

LEGAULT, Washington, D. C.

Neuropathology

HISTOPATHOLOGICAL FINDINGS IN GENERAL PARESIS [DEMENTIA PARALYTICA] AFTER PENICILLIN TREATMENT. ROBERT H. F. SMITH and VAMBERTO de MORAIS, J. Ment. Sc. **94**:70 (Jan.) 1948.

In spite of several reports of deaths during or following penicillin therapy, there have been no recorded neuropathologic studies. Smith and de Morais describe the cerebral lesions in 4 patients with dementia paralytica who died several weeks after parenteral therapy with penicillin in total doses of 2,400,000 to 4,800,000 units, amounts conceded to be insufficient. Two of the patients, however, had shown clinical, as well as serologic, improvement. The 2 unimproved subjects had juvenile dementia paralytica of long standing, with a prognosis equally poor with malarial therapy.

The reaction for iron was positive in all 4 brains, but distinctly less marked in the 2 cases in which clinical improvement followed treatment. No spirochetes were found in any of the brains. The patients with the juvenile form showed no mitigation of the characteristic inflammatory reaction of dementia paralytica. In this connection the possibility is raised of the antibiotic's producing an initial exacerbation of inflammation, like that stated sometimes to occur in malarial therapy. Autopsies on the 2 benefited patients, on the other hand, demonstrated histopathologically a degree of infiltration clearly below the average for dementia paralytica, and entirely comparable to that observed after a successful course of malaria. This result suggests that treatment with penicillin alone is capable of influencing the pathologic progress of dementia paralytica.

BEATON, Tucson, Ariz.

HISTOLOGICAL STUDY OF ONE HUNDRED AND THIRTY MENINGIOMAS. IVAN BERTRAND, J. GUILLAUME and ION OLTEALU, Rev. neurol. **80**:81 (Feb.) 1948.

The authors use the Globus classification of meningiomas as a point of departure, stressing the frequency of intermediate forms. They divide their material into five main types: (1) undifferentiated, or mesenchymatous; (2) omniform, or primitive; (3) fibroblastic; (4) arachnoidal, and (5) pial.

1. Mesenchymatous type. This tumor has a uniform structure and appears as a solid mass in which nuclei are scattered in a diffuse manner without systematization, the whole resembling fetal mesenchyme. In some portions, the nuclei are heaped up and intensely basophilic, forming germinal centers. The cell boundaries are generally indistinct. The cells may be somewhat uniform. There is moderate development of collagenous tissue. Vascularization is well developed, and the vessels may show hyaline degeneration of their walls. There is patchy necrosis, which may go on to cyst formation. Chromatolysis is frequent. Malignant degeneration, giant cells, multilobulated nuclei and multiple nucleoli are rather frequent.

2. Omniform type. This meningioma reproduces the structure of the primitive meninges before they have divided into ectomeninges and endomeninges, and it may reproduce various structures of the meningeal layers in adults. As a whole, the elements of the tumor are more developed than the mesenchymatous type, and there are numerous well developed capillaries and epithelioid cells. Collagenous tissues show a structure similar to that found in the dura, and there are bony inclusions. Germinal centers are still frequent, but there is a tendency to separation by collagenous and bony trabeculae; this tendency may go on to massive sclerosis. Vascularization is well developed. One of the essential characteristics is osteogenesis. Regressive phenomena are frequent and varied and include hyaline degeneration and calcification. There may be necrosis. Only 3 of 30 meningiomas of this type showed malignant features, which consisted of frequent mitosis, extensive necrosis and giant cells, but there was no infiltration or invasion.

3. Fibroblastic type. The tumor is strongly adherent to the dura, of firm consistency and very slow growing. It consists of fibroblasts, mixed with numerous collagenous fibers with zones of calcification and osteogenesis. The cells are almost always fusiform. There are numerous whorled figures, and there may be a palisade arrangement and strong resemblance to neurinoma. Vascularization is usually moderate. A malignant tendency is totally lacking in this form. The authors describe 2 cases of mixed neurinoma and meningioma.

4. Arachnoid type. In this type, the most developed elements reproduce the structure of the leptomeninges and correspond essentially to the endothelial cells of the arachnoid. Fibroblastic and vascular participation is moderate. The essential characteristic is a lobulated disposition of the neoplastic elements in onion bulb formation. The vessels are not abundant but are well developed. The degenerative phenomena are varied. Calcification is frequent. Histologic signs of malignancy are difficult of interpretation.

5. Pial type. This tumor is essentially vascular and is formed almost exclusively of elements of pial origin: capillaries, sinusoids and foam cells. The 8 tumors of this type were subdivided into pial hemangioendothelioma, 1 case; pial hemangioma, 3 cases; pial psammoma, 2 cases; melanosarcoma, 1 case, and sarcoma of the pia, 1 case. The authors state that, in their opinion, this type does not differ from the mesenchymatous type except in clear predominance of angioblastic tissue.

The authors stress the extreme polymorphism of the meningiomas, but this does not lead them to agree with Cushing and Eisenhardt in the division of these tumors into thirty subtypes. They believe it more practical to divide the tumors into the

five types, admitting that there are numerous subtypes and that a thorough examination of any one tumor may reveal differences from one area to another. They also remark that histologic evidence of malignancy in these tumors does not mean clinical malignancy.

LEGAULT, Washington, D. C.

PATHOLOGIC ANATOMY IN TWO CASES OF MYASTHENIA GRAVIS. P. I. ELIZALDE and J. R. MANZUOLI, Rev. Asoc. med. argent. **61**:661 (Sept.) 1947.

Elizalde and Manzuoli found tumors of the thymus gland in 2 patients with typical myasthenia gravis who died at 40 and 41 years of age, respectively. Many tumors of the thymus have been reported in cases of the disease since the first description, by Weigert, of such an association (1901). In 1 case a true blastomatous process was observed with hyperplasia of epithelial cells, and a diagnosis of thymoepithelioma was made. In the other case, there was hyperplasia of normal thymus tissue.

N. SAVITSKY, New York.

Diseases of the Brain

SYNDROME OF VISUAL ALEXIA WITH COLOUR AGNOSIA. E. STENGEL, J. Ment. Sc. **94**:46 (Jan.) 1948.

Stengel studied 2 cases of visual alexia and color agnosia in which the symptoms were not part of a general visual agnosia or of a speech disorder. Clinically, word blindness is usually associated with color agnosia and is now understood to be caused by impairment of the same function which underlies amnesic aphasia.

Both patients had apparently suffered cerebral vascular accidents. It is of interest that both had exhibited transient psychotic signs, with shock therapy successful in the second case. Each man presented a symptom complex of word blindness with partial letter blindness, color agnosia and homonymous hemianopsia with intact perimacular fields, without other gross aphasic, agnosic or apractic defect. The first subject is still living, while the second died after development of right hemiplegia, at first more pronounced in the arm than in the leg. No autopsy was obtained; so pathologic proof of responsible lesions is lacking.

Only a few cases have been recorded in which this combination of symptoms was not complicated by severe aphasia and disorientation in space. The partial letter blindness of these 2 patients points to an occipital lesion. The types of letters which were not recognized were the same as those which patients with impairment of epicritic cutaneous sensibility find difficult to identify when written on the skin, a phenomenon suggesting a relation between perception and recognition. The first patient showed some agraphic difficulties, attributable to the alexia, except for omission of punctuation and failure to capitalize, errors which remain unexplained. Both patients could read arabic numerals but not Roman figures, an observation which is understood on the basis of late acquisition and disuse. Though neither patient was truly color blind, each had difficulty in sorting colors, possibly owing to impairment in categorical thinking. At least it is suggested that the syndrome is not a part of an aphasic disorder, as Nielsen has contended. Localization in the lingual and fusiform gyri is favored. It is believed that visual alexia and color agnosia do not result from lesions of the angular gyrus, as previously conceived, for pure word blindness has never been found associated with Gerstmann's syndrome of finger agnosia.

BEATON, Tucson, Ariz.

THE SYNDROME OF ALEXIA AND AMNESIC APHASIA: SUBARACHNOIDAL HAEMORRHAGE WITH SYMPTOM OF PARTIAL OCCLUSION OF THE SPINAL SUBARACHNOIDAL SPACE. R. KLEIN and J. H. ATTLEE, J. Ment. Sc. **94**:59 (Jan.) 1948.

Klein and Attlee report the case of a woman aged 47 who suddenly became semicomatose after a fortnight of general malaise and headache. After lumbar puncture she regained responsiveness, and in subsequent days examination disclosed disorientation in all spheres, severe memory loss, acalculia, amnesic aphasia, word blindness, upper right homonymous quadrantic hemianopsia, paraparesis of the legs and pyramidal signs, somewhat more pronounced on the right. The history, clinical findings, meningeal signs and hemorrhagic spinal fluid pointed to a diagnosis of subarachnoid bleeding, probably from a ruptured aneurysm. On lumbar puncture the dynamics suggested partial occlusion of the spinal subarachnoid space, which was felt to account for the confusing pyramidal signs. These cleared up shortly, while the special aphasic defects were still present three months later. The acute mental picture, thought to be due to extravasation around the diencephalon, also disappeared rapidly.

Some aspects of the patient's amnesic aphasia appeared to sanction Goldstein's interpretation of the symptom as a malfunction in categorical thinking, but her capacity for abstract and representational thought, her easy grasp of meaning and her aptitude in interpreting proverbs led to the conclusion that amnesic aphasia is not the expression of a general thought disorder but is an isolated and independent defect, which consists of an inability to mobilize word material. The alexia included letter blindness as well as word blindness, with no difficulty in the recognition of objects or pictures, which would seem to rule out peripheral factors, such as the restriction of visual fields. A remarkable reaction of the patient was her ability to interpret words or parts of sentences without being able to read them or being able to produce the exact word or phrase. This was similar to her amnesic aphasic, in which she could grasp the meaning but could not get hold of the exact expression she desired, a reaction indicating that there is a common factor which interferes with mobilization of the written word, as well as with that of the spoken word. A psychologic explanation may thus be provided for the syndromal appearance of amnesic aphasia and alexia. It is felt, however, that the alectic picture in this case was predominantly of a visual agnostic order, with an amnesic factor partially responsible. The third semipermanent symptom was acalculia, which has only rarely been found to accompany word blindness. Perhaps in a person whose calculations are integrated with visual imagery or based on reading procedure, alexia could secondarily lead to difficulties in the arithmetical function.

From the investigations of others, it is surmised that the alexia was due to involvement of the left lingual gyrus, with the upper quadrantic nature of the hemianopsia pointing to an interruption of the lower fibers of the optic radiation, in agreement with destruction basally located. Word blindness occurs in damage to the occipitotemporal region. The combination of the two symptoms may be explained by an extension of the lesion to the temporal lobe.

BEATON, Tucson, Ariz.

CEREBELLAR SYNDROME OF FRONTAL ORIGIN—CLINICAL AND ANATOMIC OBSERVATIONS. C. FERRERO, Encephale **37**:147, 1948.

The problem of a cerebellar syndrome of frontal origin has not been completely resolved. The author reports a case which is of some interest in this respect. The patient had what was, in effect, a unilateral cerebellar syndrome combined with vestibular disturbance of the opposite side (dissociated cerebellovestibular syndrome).

A white man aged 40 was admitted to the hospital with a history of severe attacks of intense headache with vertigo, buzzing in his ears and marked disturbances of gait, with falling to the left. These attacks had occurred seven to eight times a day for three months. On his admission, the neurologic status was normal except for hypotonia of the lower extremities. The neurologic signs, which at first occurred only during the attacks, gradually became more permanent but continued to vary in intensity. They consisted of a right hemicerebellar syndrome combined with discordant, variable vestibular signs. During the last three days of his illness, slight sensory changes to pinprick in the lower extremities, less on the right than on the left, were noted. At the same time a discrete pyramidal syndrome, more definite on the left side than on the right, was also noted. The cerebrospinal fluid and the eyegrounds remained normal throughout the course. The patient grew suddenly worse and was transferred to the surgical service with a diagnosis of neoplasm of the posterior fossa. The ventriculogram revealed a normal left frontal horn, but the right frontal horn was twice as large as the left. He died within twenty-four hours after decompressive trepanation. Autopsy revealed a small cell cystic astrocytoma of the right frontal lobe, extending forward as far as the anterior horn and posterior to the parietal lobe. The cerebellum showed merely a few small, discrete, recent subcortical hemorrhages.

The author discusses the literature of this problem, which was first established by Claude and Lhermitte in 1916. Clinical, anatomic and experimental evidence have often been discordant; yet the authenticity of such a syndrome is established. The physiologists have often disputed it, but after the work of Delmas-Marsalet and others even they have fully accepted its existence. The surgeons, following Cushing, have been well aware that often a tumor of the frontal lobe may be mistaken for a cerebellar tumor. Diagnostically, the electroencephalogram and the encephalogram are the surest aids in establishing the proper localization. The cerebellar and vestibular signs are usually discordant and confusing; and this very central disharmony is an argument for a frontal, rather than a cerebellar, lesion.

ZINKIN, Fort Worth, Texas.

TORSION SPASM OF ZIEHEN AND OPPENHEIM IN AN ARYAN WOMAN. GILBER MYLE, J. belge de neurol. et de psychiat. **47**:666 (Nov.) 1947.

Myle reports the case of a woman aged 29 who first showed torsion movements of the arms and head at the age of 3 years. The mother, aged 55, showed muscular hypertonus and torsion movements of the right side of the body together with an explosive, guttural speech. There was also a family history of chronic dermatitis, probably of allergic origin. The author raises the question whether the presence of these two conditions in the same family is incidental, or whether the two, each of which involves a tissue of ectodermal origin, may not constitute different aspects of a single hereditary affliction.

DEJONG, Ann Arbor, Mich.

CEREBRAL COMPLICATIONS OF LYMPHOGRANULOMATOSIS. DENISE LOUIS-BAR, J. belge de neurol. et de psychiat. **47**:703 (Dec.) 1947.

The complications referable to the nervous system of lymphogranuloma may assume any of three pathologic forms. Vascular changes and granulomas of the pachymeninges and leptomeninges may cause medullary complications, either through ischemia or compression and invasion of the cerebrospinal axis. The general toxic effects of the disease may cause changes in metabolism of the nervous system, with symptoms of acute polyneuritis, subacute combined sclerosis or Wer-

nicke's polioencephalitis. In exceptional cases there may be intracerebral development of lymphogranulomatous tissues, either by extension along the pial vessels or metastasis, with the production of an axial or corticoaxial encephalitis.

DEJONG, Ann Arbor, Mich.

THROMBOSIS OF THE INTERNAL CAROTID ARTERY AND ITS BRANCHES. JEAN N. TAPTAS and JEAN PECKER, Rev. neurol. **80**:3 (Jan.) 1948.

The authors report in detail 5 cases of thrombosis of the internal carotid artery or of its branches. They list as the chief etiologic factors trauma, syphilis and other infection, intoxications, and intrinsic vascular disease, such as aneurysm and Buerger's disease (thrombangiitis obliterans). They point out that thrombosis due to trauma to the neck may be delayed in onset. The clinical manifestations of thrombosis of the carotid artery are those of cerebral type and those referable to the cranial nerves. Cerebral signs develop, usually after prodromes of paresthesias in the hand especially, or of seizures, into hemiplegia, aphasia, hemianopsia and mental difficulties. Headache may be severe and may be due to meningeal bleeding. The major differential problem concerns tumor, which is best ruled out by arteriography.

The second, third, fourth, fifth and sixth cranial nerves may be involved, owing to proximity to the thrombosis, the pathologic reaction to which extends outside the vessel wall. In such instances the major differential problem is that of aneurysm.

LEGAULT, Washington, D. C.

STRÜMPELL-LORRAIN DISEASE (FAMILIAL SPASTIC PARAPLEGIA). C. PREIONI, D. SNEIDER and I. BENZECRY, Prensa med. argent. **34**:1318 (July) 1947.

The authors report 2 cases of familial spastic paraplegia in a brother and sister. The sister, 18 years of age, had had difficulty in walking since early childhood and was never able to walk properly. There was some mental retardation. Examination disclosed signs referable to the pyramidal tract bilaterally with weakness and increased tonus in all the limbs; there were no sensory changes. The brother was examined at the age of 26, ten years after onset of the illness with increasing stiffness of gait. Seven years after onset he was unable to walk. Examination showed more pronounced mental deficiency than in the sister. Neurologic examination revealed bilateral pyramidal tract signs and spasticity.

N. SAVITSKY, New York.

VISUAL FIELD STUDIES IN FIFTY-TWO CASES OF CHIASMAL ARACHNOIDITIS. E. ADROGUE and M. A. DIEZ, Primer Cong. sudam. de neurocir., Actas **1**:205 (March 1-4) 1945.

The changes in the visual field in 52 cases of chiasmal arachnoiditis were almost always bilateral; they were confined to one eye in only 2 cases. The initial change was usually enlargement of the blindspots, with later involvement of the peripheral fields. In only 3 cases were there enlarged blindspots with normal peripheral fields. Scotomas appeared later. There were 18 cases with scotomas: 5 central, 10 cecocentral and 3 paracentral. The peripheral visual fields were symmetric in only 2 cases. The changes in the visual fields usually began in the inner fields with characteristic irregularity and asymmetry. Temporal hemianopsia was found in 9 cases, nasal hemianopsia in 10 cases, superior altitudinal hemianopsia in 3 cases, inferior altitudinal hemianopsia in 9 cases and concentric constriction of the fields in 18 cases.

N. SAVITSKY, New York.

PROJECTION OF MACULA ON STRIATE AREA. E. ADROGUE and M. A. DIEZ, Primer Cong. sudam. de neurocir. Actas **1**:504 (March 1-4) 1945.

In a man aged 49 with a verified metastatic tumor in the region of the left occipital pole, the tumor was found to be mainly above the calcarine fissure. The authors point out that this is the first case reported of a verified tumor in a patient who showed right inferior absolute homonymous central scotomas which were slightly asymmetric, with preservation of the peripheral field. The maculas were definitely and sharply divided in the center. This case serves as additional evidence that the maculae are projected on the posterior part of the area striata.

N. SAVITSKY, New York.

POSTECLAMPTIC EPILEPSY. CARLOS PINEDO and NORBERTO QUIRNO, Rev. Asoc. med. argent. **61**:715 (Oct.) 1947.

Pinedo and Quirno found only two articles in the literature concerned with recurrent convulsive seizures following eclampsia. They report the case of a woman aged 24 who had onset of edema and eclamptic attacks during the sixth month of pregnancy. Loss of consciousness continued after delivery with a few convulsions, right hemiplegia and aphasia, which lasted fifteen days. After delivery the patient had a grand mal attack every month, the convulsions being severer on the right side. The blood pressure was 130 systolic and 80 diastolic. Neurologic examination showed only weakness of the lower right side of the face. Pneumoencephalographic and roentgenographic studies of the skull revealed nothing significant. An electroencephalogram showed an epileptic dysrhythmia, especially in the left frontoparietal region. Rosenbaum and Nalthy have shown that 65 per cent of women with toxemia of pregnancy with eclampsia have cerebral dysrhythmia similar to that seen in epilepsy. Similar electroencephalographic changes were found in only 10 per cent of patients who did not have convulsions. These facts indicate the existence of a predisposition to epileptic attacks in women with eclampsia, who have convulsions during eclampsia or as its sequel.

N. SAVITSKY, New York.

LOCALIZATION OF INTRACRANIAL TUMORS BY ELECTROENCEPHALOGRAPHY. FRITZ BUCHTHAL and EDUARD BUSCH, Acta psychiat. et neurol. **23**:9, 1947.

Buchthal and Busch analyzed electroencephalographic records of 60 patients with surgically and pathologically verified cortical and subcortical tumors. A three channel electroencephalograph was used, with unipolar and bipolar leads. With unipolar leads, the affected hemisphere was correctly localized in 72 per cent of subjects, wrongly localized in 10 per cent and not localized at all in 18 per cent. With bipolar leads, phase reversal was felt to be the most valuable aid in localization, and this phenomenon was found to correspond to the tumor in 51 per cent of the patients examined. In part of the cases in which phase reversal did not occur a tumor was localized by determining the area in which low frequency potentials were chiefly concentrated. A percentage identical with that of localization with unipolar leads was found with this method. The authors believe that abnormal electrical activity is produced by the zone of tissue which borders on the tumor, the oxygen supply of which is affected by direct or indirect pressure from the latter.

DONALD, Philadelphia.

Diseases of the Spinal Cord

EDEMA OR HERNIATIONS OF FAT LOBULES AS A CAUSE OF LUMBAR AND GLUTEAL "FIBROSITIS." W. S. C. COPEMAN and W. L. ACKERMAN, Arch. Int. Med. **79**:22 (Jan.) 1947.

Fibrositis as a clinical entity has long been accepted in England, where it constitutes about 12 per cent of all medical cases. Copeman and Ackerman were impressed with the high incidence of this disorder in a large body of highly selected young men. The condition was found to be associated universally with "trigger pains," from which pain was widely referred. The exact situation in which these occurred in a series of patients was charted, and a "pain pattern" of definite shape emerged. From above downward, the locations in which a majority of the trigger points cluster are as follows: the point where the outer edge of the sacrospinalis muscle meets the posterior costal margin; a spot about 2½ inches (7.4 cm.) above the iliac crest, which is the level at which the latissimus dorsi muscle often crosses the edge of the sacrospinalis muscle; another spot 1 inch (2.5 cm.) lower, and another at the edge of the sacrospinalis muscle just above the iliac crest. In the gluteal region, these points may be found all along the crest of the ilium and for a distance about 2 inches (5 cm.) below it. They may also be found along the sacroiliac junction, where the deep fascia is attached. They are much less commonly found elsewhere in the buttock.

The authors confirmed previous observations that these trigger pains may arise during any pyrexial illness, or as the result of trauma, and that the subjective pain often disappears, but the point remains and can be detected by its tenderness on palpation. It can be reactivated subsequently and may gradually become the seat of chronic pain.

The back was carefully dissected in 14 bodies, with particular reference to the sites at which pain had chiefly been found to occur. It was found that a "basic fat pattern" was constantly present, even in the most cachectic subjects, in whom all other fat was absent. This "fat pattern" was observed to correspond with the "pain pattern" already charted, both in situation and in shape.

The observations show that the production of pain at these trigger points takes place in certain fibrofatty tissue, and not in the muscles, as has often been stated. The local lesion demonstrated in those cases in which biopsy was performed consisted of an increase in the volume of fat lobules in situations where expansion was normally limited by an unyielding fibrous capsule. In 1 case increased tension in the lobule appeared to be the result of an old hematoma.

In the clinical cases described by the authors, the process had progressed to actual herniation of the fat lobules through weak spots in the fibrous compartment or capsule. The causative nature of these lesions seemed to be confirmed by the patient's freedom from pain subsequent to the removal of the herniations.

Exploration of the painful area in a small series of cases of periarticular fibrositis ("panniculitis") of the menopausal type suggested that a similar mechanism might also be responsible for the pain in these cases.

Physiologic principles underlying certain lines of physical treatment commonly employed in the treatment of fibrositis are shown to be rational for the pathologic conditions described. The authors employed the injection of procaine hydrochloride, and after injecting 10 to 20 cc. of 1 per cent solution they teased the nodule. This process consisted of employing the cutting point of the needle in such a way as to "undercut" the nodule—much as a tenotomy knife might be used—in an attempt to divide the pedicle of the herniated portion, should there be one, and to disrupt any neighboring lobules which may be sharing in this process.

GUTTMAN, Philadelphia.

Book Reviews

Rehabilitation of the Physically Handicapped. By Henry H. Kessler, M.D., Ph.D. Price, $3.50. Pp. 274, no illustrations. New York: Columbia University Press, 1947.

This fascinating book impresses one with the authoritative presentation of a subject about which much has been written. The author, a worldwide authority on reconstructive surgery, discusses the many factors which enter into total rehabilitation of the severely handicapped person. He deftly presents the problems of the many types of handicap encountered in medical and surgical practice. The problems of the disabled industrial worker, the wounded veteran, those injured through motor accidents, the crippled child and persons chronically disabled by cardiovascular disease, tuberculosis, arthritis and crippling diseases of the central nervous system, each, in turn are analyzed and the special problems of rehabilitation are set forth. The author emphasizes the rehabilitation of the patient as a whole, stressing not only physical but psychic adaptation to the environment in which the patient seeks acceptance.

Authoritative and convincing figures are presented throughout the text, and the reader is impressed with the extent of existing problems of rehabilitation. A plea is made for accumulated data in clarifying and meeting the needs of the rehabilitated patient. The economic and social problems of the handicapped are kept continually in focus. The progress made over the years in meeting these problems is noted, with emphasis on the changing attitude, both in lay and in medical circles, toward the handicapped person.

The position of federal, state and private institutions in assisting the handicapped in securing the necessary, but otherwise unobtainable, assistance during rehabilitation is explained. Insurance, pensions and other financial aids are discussed. Weaknesses of practices as they exist in workmen's compensation laws throughout the country are explained. The employers' attitude toward employment of the handicapped is factually presented.

Selective placement of the handicapped after consideration of job requirements and the degree and type of handicap is treated realistically. The efficient rating of the handicapped when so employed and the minimal hazard to second injury of such employees are pointed out.

Many case histories, both medical and surgical, are presented to show the manner in which comprehensive teamplay may result today in rehabilitation of many previously neglected persons.

The modest self effacement of a man who for thirty years has applied himself as an ingeniously successful surgeon, humanitarian, physician and trail blazer to the problems of rehabilitation makes this book the more fascinating.

This work is among the most carefully prepared, complete, comprehensive and convincing books on rehabilitation which has as yet made its appearance. It will be equally useful to the medical profession, to the student and to others concerned with rehabilitation, as well as to the lay population, whose assistance in total rehabilitation is valuable and necessary.

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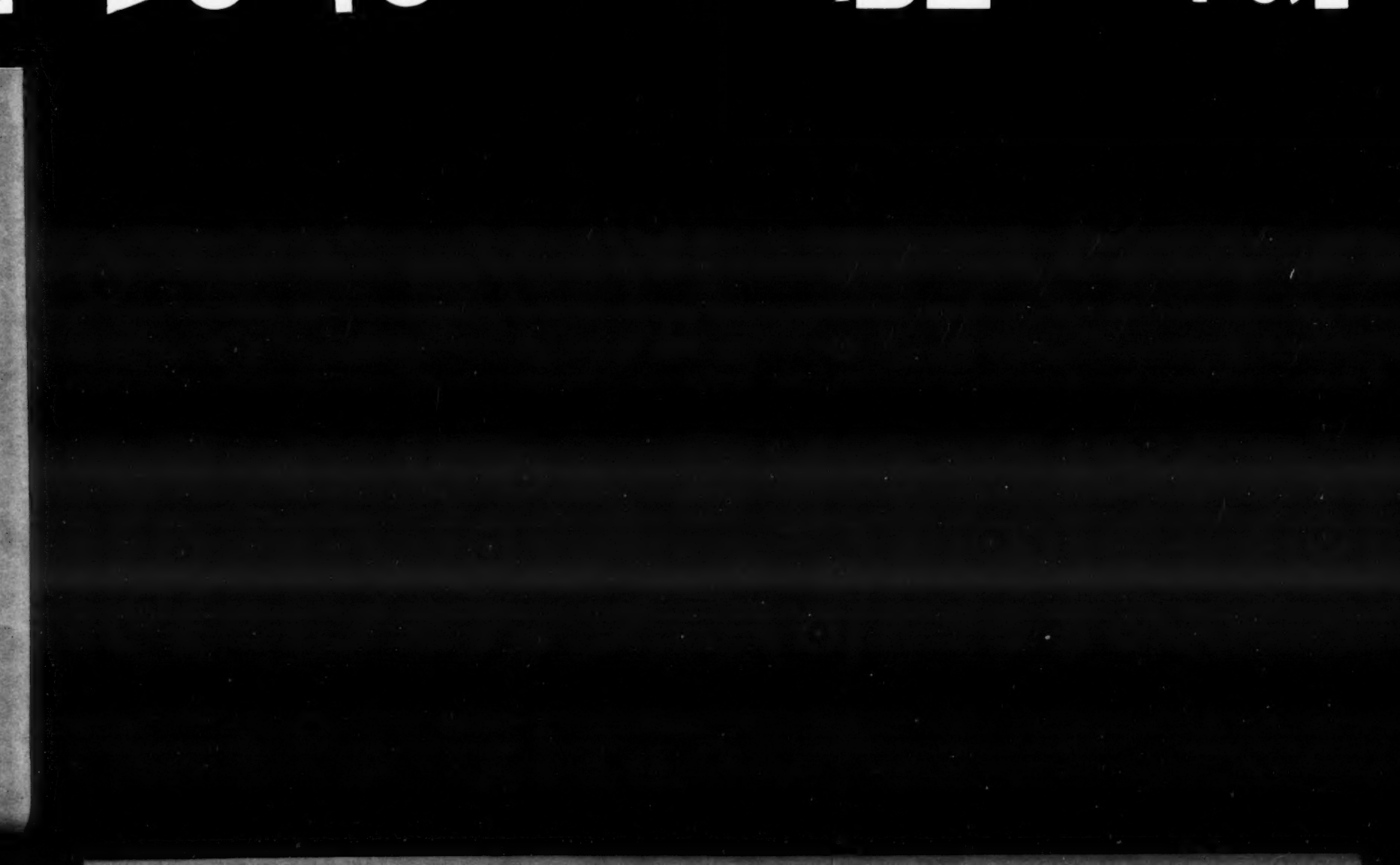
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